Marshall, Michael

From: Thomas, George
Sent: Friday, February 15, 2013 10:14 AM
To: Erickson, Alice
Cc: Sheikh, Abdul; Graves, Herman; Marshall, Michael
Subject: RE: Revised ACI 318-71
Attachments: Assessment of ACI 318-71 gt 2-15-13.docx

Alice,

The attached has a mark-up of my comments and perspectives.

Thanks.
George

From: Erickson, Alice
Sent: Tuesday, January 29, 2013 2:30 PM
To: Marshall, Michael
Cc: Sheikh, Abdul; Thomas, George; Graves, Herman
Subject: Revised ACI 318-71

Michael,

I've attached the revised version of the ACI 318 paper. I merged the comments that I received from Bill Cook and Niklas Floyd and you can see the changes I made in response to the comments in track changes. For the comments that did not result in revisions, I provided a comment to explain why. I haven't discussed these revisions with Bill or Niklas yet, but would like to share why I made the changes that I did. Please provide me any comments or feedback so we can send it to OGC for review and comments.

Abdul, George, and Herman,

If you have any additional comments or revisions to see necessary, please let me know and I'll be happy to discuss.

Thanks,

Alice Erickson
General Engineer
Office of Nuclear Reactor Regulation
Division of License Renewal
Aging Management of Structures, Electrical, and Systems Branch

Mail Stop: O-11F1
Phone: (301) 415-1933
Email: Alice.Erickson@nrc.gov

B92

January 29, 2013

MEMORANDUM TO: ASR Working Group

FROM: Michael Marshall, Branch Chief

SUBJECT: POSITION PAPER: ASSESSMENT OF ACI 318-71 AS DESIGN BASIS FOR CATEGORY 1 CONCRETE STRUCTURES AFFECTED BY ALKALI-SILICA REACTION AT SEABROOK STATION

The purpose of this paper is to document the staff's position regarding the applicability of American Concrete Institute (ACI) 318-71, "Building Code Requirements for Structural Concrete," and understanding of the guidance provided in Chapter 20 of ACI 318-71 as it relates to the Seabrook Station current licensing basis.

The staff has performed a thorough review of the relevant regulatory requirements, guidance documents, industry codes and standards, and Seabrook Station UFSAR and has determined that a distinction should be made between the method of evaluation relied upon for design considerations, i.e. the strength design method of ACI 318-71, and methods of evaluation for existing structures for specific degradation mechanisms and effects. The Seabrook Station UFSAR clearly documents the strength design method of ACI 318-71 along with NUREG-0800, "Standard Review Plan as the design bases for the Category I Structures, with the exception of primary containment. However, the method of evaluation for existing structures for degradation mechanism is not ~~clearly defined~~part of the licensing basis described in the UFSAR.

Enclosure: Assessment of ACI 318-71 as Design Basis for Category 1 Concrete Structures Affected by Alkali-Silica Reaction at Seabrook Station

CONTACT: Alice Erickson, NRR/DLR/RASB
301-415-1933

Assessment of ACI 318-71 as Design Basis for Category I Concrete Structures Affected by Alkali-Silica Reaction at Seabrook Station

Written By:
Alice K. Erickson

Peer Reviewed By:
Abdul Sheikh
Herman Graves
George Thomas

~~November 9, 2012~~January 29, 2013

BACKGROUND

Historically, Seabrook Station has experienced groundwater infiltration through below grade portions of concrete structures. In the early 1990's, an evaluation was conducted to assess the effect of groundwater infiltration on the serviceability of concrete walls and concluded that there would be no deleterious effect, based on the design and placement of the concrete and on the non-aggressive nature of the groundwater. However, in 2009, NextEra tested seasonal groundwater samples to support the development of the License Renewal Application (LRA) and the results showed that pH values were between 5.8 and 7.5, chloride values were between 19 ppm and 3900 ppm, and sulfate values between 10 ppm and 100 ppm, indicating that the groundwater had become aggressive [pH < 5.5, chlorides > 500 ppm, or sulfates > 1500 ppm]. Subsequently, in conducting a comprehensive review of the possible effects on concrete structures, in early to mid-2010, the licensee performed in-situ penetration resistance testing (PRT) and compression testing of concrete cores from the affected areas in the "B" electrical tunnel of the control building. The results showed a reduction in compressive strength and modulus of elasticity of the affected concrete. In September 2010, the applicant confirmed the presence of Alkali-Silica Reaction (ASR) through petrographic examination of samples taken from the concrete cores of the "B" electric tunnel.

Comment [g1]: All this is not relevant to this paper. It would suffice to say that:

In August 2010, during a license renewal assessment, Seabrook Station reported the presence of ASR degradation of concrete in below-grade walls of several Category 1 structures with groundwater intrusion. Initial testing of core samples indicated a reduction in compressive strength and elastic modulus properties.

The licensee has made two prompt operability determinations (PODs) to address the effects of this issue for potentially affected structures. The first addresses the ~~reduced concrete properties~~reduction in concrete compressive strength and modulus of elasticity below grade in the "B" electrical tunnel exterior wall, and the second addresses the reduced concrete modulus of elasticity below grade in the containment enclosure building (CEB), residual heat removal (RHR) equipment vaults, emergency feedwater (EFW) pumphouse, diesel generator fuel oil tank rooms, and some additional other Cate~~r~~gory I Structures. These additional Category I structures, identified as having the potential presence of ASR as a result of an extent of condition survey, include the condensate storage tank enclosure, control building makeup air intake, service water cooling tower, "A" electrical tunnel, fuel storage building, east pipe chase, west pipe chase, pre-action valve room, primary auxiliary building, service water pump house, mechanical penetration area, and waste process building. Except for the primary containment structure, the Seabrook concrete structures that have been identified thus far as affected or potentially affected by ASR generally fall under the classification of "Other Category 1 Structures" described in UFSAR Section 3.8.4. As of June 2012, both PODs conclude that the ASR-affected structures are *operable but degraded*, and *below full qualification*. NUREG-1430, "Standard Technical Specifications," defines *operable/operability* as "...capable of performing its specified safety function." RIS 2005-20, Revision 1, which includes NRC Inspection Manual Part 9900 as an attachment, defines *degraded condition* as "one in which the qualification of an SSC or its functional capability is reduced." It further defines *full qualification* of an SSC as one that "conforms to all aspects of its CLB, including all applicable codes and standards, design criteria, safety analyses assumptions and specifications, and licensing commitments." Based on the definitions provided in Inspection Manual Part 9900, the "below full qualification" aspect of Seabrook Station's operability determination suggests that Seabrook Station is not meeting some aspect of its CLB. The licensee will have to resolve the current PODs with respect to the CLB, by a final corrective action in accordance with its procedures for operability determinations and functionality assessments, as part of its action plan to comprehensively address and manage the ASR degradation issue at the site.

Comment [n2]: What were these concrete properties? (e.g. what makes these properties different vs. the reduced elasticity modulus mentioned in the next sentence)

This paper is not intended to cover all requirements that must be met for compliance with the CLB, but to focus on understanding the applicability of American Concrete Institute (ACI) 318-

71, "Building Code Requirements for Structural Concrete," to which the affected structures were designed.

ACI 318-71 DOCUMENTED AS DESIGN BASIS

Seabrook Station's Updated Final Safety Analysis Report (UFSAR) Section 3.8, "Design of Category I Structures," identifies the 1971 version of American Concrete Institute 318 (ACI 318-71), "Building Code Requirements for Reinforced Concrete (with Commentary)" as the applicable Construction Code for Category I structures, exclusive of the primary containment structure. UFSAR Subsection 1.8, "Conformance to NRC Regulatory Guides" indicates that although compliance with Regulatory Guide 1.142, "Safety-Related Concrete Structures for Nuclear Power Plants (Other Than Reactor Vessels and Containments)" was not required and that ACI 349-76, "Code Requirements for Safety-Related Structures" was not used as a design and construction standard, the design and construction of the structures do fulfill the intent of the requirements set forth in the publication and in Regulatory Guide 1.142. Further, UFSAR Subsection 1.8 clearly indicates that the "loads and load combinations were taken directly from the USNRC Standard Review Plan and ACI 318[-71]" and that "structural analysis and design were consistent with the requirements of the [USNRC] Standard Review Plan (SRP) [NUREG-0800] and ACI 318[-71]."

The Seabrook Station UFSAR Sections 3.8.3 and 3.8.4 clearly documents the [ultimate] strength design method of ACI 318-71 Code along with the NUREG-0800 SRP as the design basis for the Category I Structures, except the primary containment. The basic load combinations considered in the design basis of each seismic Category 1 structure are given in UFSAR Table 3.8-16. Thus, ACI 318-71 strength design was used in conjunction with load combinations in the referenced UFSAR table as the current licensing basis to demonstrate compliance with GDC 1, 2 and 4, and to ensure that the intended functions would be accomplished for these concrete structures. ~~Therefore, demonstration that those structures now affected by ASR still meet the strength design requirements of ACI 318-71 under design basis loads and load combinations in the UFSAR, should be sought for compliance with Seabrook Station's current licensing basis (CLB).~~

DISCUSSION ON ACI 318-71

ACI 318-71 is a Construction Code written in the context of the scope of new design and construction. The empirical relationships between concrete compressive strength and other material/mechanical properties (such as tensile strength, shear strength, bond, modulus of elasticity etc.), defined in this Code and relied upon for design, are based on performance and test data of normal concrete. These equations do not account for the effects of ASR and may not remain valid for ASR-affected concrete depending on the severity of the degradation ; and therefore, should ~~not be relied upon to demonstrate that the Code requirements are satisfied, unless proven otherwise~~be treated with caution for ASR-degraded structures. The technical basis for establishing design adequacy of reinforced concrete structural systems with ASR degradation is not covered by the ACI 318-71 Code. ~~However, ACI 318-71 Chapter 20, "Strength Evaluation of Existing Structures" does provide guidance for structural assessments when doubt develops concerning the safety of a structure.~~ ~~Although ACI 318-71 is a Construction Code, a review of this Code identified two sections as being useful in considering NextEra's approach to demonstrating that the ASR-affected structures continue to meet the intent of ACI 318-71.~~

Comment [g3]: This is essentially repeated in the next paragraph.

Comment [g4]: This is just historical information - not needed in this paper. We need to just stick to Section 3.8, which is where design basis of structures is described.

Comment [w5]: Although we believe this statement is correct, it may not be, in that, it may be dependent upon the degree of ASR expansion and/or confinement. If we understand NextEra' expectation for testing large-scale specimens, they intend to show by testing that the Code relationships are being maintained, even in ASR-affected structures.

Alice: We know that the relationships are based on the performance and test data of normal concrete which is stated in the prior sentence. The "unless proven otherwise" is intended to communicate that they may be able to demonstrate the relationships still remain valid for ASR-affected concrete.

Comment [n6]: This is a slightly repetitive statement since the two sections identified are discussed in the next two paragraphs. I recommend deleting it.

ACI 318-71 Chapter 1, Section 1.4, "Approval of Special Systems of Design or Construction," states that "[t]he sponsors of any system of design or construction within the scope of this Code, the adequacy of which has been shown by successful use or by analysis or test, but which does not conform to or is not covered by this Code, shall have the right to present the data on which their design is based to a board of examiners appointed by the Building Official. This board shall be composed of competent engineers and shall have the authority to investigate the data so submitted, to require test, and to formulate rules governing the design and construction of such systems to meet the intent of this Code. These rules when approved by the Building Official and promulgated shall be of the same force and effect as the provisions of this Code." This section is intended to allow new developments and methods of design, new materials, and new uses of materials that have not been covered by the code in design and construction provided their adequacy is substantiated by data. The provisions of Section 1.4 is also in the context of new design and construction. It is also stated in the commentary that the provisions of Section 1.4 do not apply to strength evaluation of existing structures under Chapter 20. Thus, Section 1.4 is not intended to apply to strength evaluation of ASR-degraded structures. Section 1.4 of the ACI 318-71 code was not used during construction and in the licensing basis for Seabrook structures.

For the purpose of completion of the above discussion, Section 1.2.3 of the Code defines the Building Official as "the officer or other designated authority charged with the administration and enforcement of this Code, or his duly authorized representative." By law, the NRC has the regulatory jurisdiction over commercial nuclear power plants in the US with the mission to protect public health and safety. Concrete structures important-to-safety have been licensed by the NRC to ACI 318-71 for several earlier plants. Therefore, in the context of ~~the C~~code terminology, the NRC would logically be considered the Building Official in this situation. Also, even though ACI 349 "Code Requirements for Nuclear Safety-Related Concrete Structures" was not published until after Seabrook Station's design was completed, Section 1.4, which is equivalent to Section 1.4 in ACI 318-71, replaced the term "building official" with "authority having jurisdiction." This is because the ACI 349 Code adapted and applied most of its provisions from ACI 318 specifically for nuclear safety-related structures (with exception of containment) and, therefore, explicitly identifies the NRC as having this authority in the definitions section of the Code. Nevertheless, it must be emphasized that the NRC (or Building Official in general) does not derive its regulatory authority from the code. It derives its authority from the applicable statute. In fact, the Code has no legal status unless it is adopted (in whole or part or conditionally) by the regulatory body having jurisdiction over the design and construction of specific facilities to protect public health and safety. Therefore, by allowing the use of ACI 318-71 strength design provisions as the licensing basis for design and construction of Category 1 structures (except containment) at Seabrook, the NRC has provided legal status to the code provisions that were used in the Seabrook safety analysis. Thus, in the context of Seabrook Station, the Building Official is the regulatory body (i.e., the NRC, noting that the authority comes from the law) that provided legal status to the code (in part or as a whole) as ~~a~~one of the means for ~~implementing~~accomplishing its public safety mission. ~~Regardless, it is important to note that the commentary for ACI 318-71, Section 1.4, clarifies that the provisions of this section do not apply to strength evaluation of existing structures under Chapter 20.~~

ACI 318-71 Chapter 20, "Strength Evaluation of Existing Structures," which again is written in the context of strength deficiencies following construction, does provide limited guidance for structural assessments when doubt develops concerning the safety of a structure. ACI 318-71 Chapter 20, "Strength Evaluation of Existing Structures," Section 20.1 states that "if doubt develops concerning the safety of a structure or member, the Building Official may order a structural strength investigation by analysis or by means of load tests, or by a combination of

Comment [n7]: Is this true? I could not find any commentary for ACI 318-71. I do know that ACI 318-11 does say this though. I recommend delete if not true.

Alice: This is true. We had a copy of the 1971 version with commentary in the library, but it has since turned up missing.

Comment [w8]: Discussion in this paragraph pertaining to the Building Official is good, but I would prefer to have this last sentence in the next paragraph as a lead-in to the Chapter 20 discussion.

Alice: I decided to keep it in this paragraph because this statement is in Section 1.4 of the ACI code, not Chapter 20.

these methods." The commentary states that typically such doubt may arise if the materials supplied are considered to be deficient in quality, if the construction is suspect, or if the structure does not satisfy the Code in some aspect. This again implies that the considerations in Chapter 20 w~~as~~ere intended to address construction defects/deficiencies in existing structures, and generally not intended for evaluation of -degradation mechanisms and effects ~~sed conditions~~, especially those that could vary with time and alter the structural behavior of concrete. Chapter 20 of the ACI 318-71 code was not used during original construction and is not part of the licensing basis of Seabrook structures.

The general requirements for analytical investigations provided for in Section 20.2 states that "a thorough field investigation shall be made of the dimensions and details of the members, properties of the materials, and other pertinent conditions of the structure as actually built." This means that the data relied upon in the analytical investigation must be based on measured properties of the in-situ conditions of the structure. Section 20.3 provides general requirements for load tests on the built structure and Section 20.4 provides requirements for load test for only flexural members. The ~~linear elastic (code basis)~~ analytical strength evaluation based on linear elastic analysis (which is the code basis) may only have some limited value for initial approximate assessment of effects of ASR. The use of conventional linear elastic analyses to assess the effect of ASR has little practical utility. The input to any analysis remains dependent upon on the interpretation of the effect of ASR degradation which is often uncertain and subjective. The in-situ load test guidance provided in Chapter 20 has significant limitations and again of very little value to address the ASR issue at Seabrook. In fact, it is not appropriate for understanding and comprehensively addressing structural behavior and performance of ASR-affected nuclear power plant structures for different critical limit states for different levels and variation of degradation with time and space. ~~The provisions of Chapter 20, especially the load tests, are generally in the context of acceptability of concrete quality of the as-built structure at the time of original construction.~~ ~~Never the less~~~~However~~Also, load tests on the as-built structure ~~does not seem like~~is not a practicable approach for the Seabrook Station ASR issue, especially for the affected below-grade structures and for performance assessment in shear, bond and anchorages for embeds and supports~~.~~and other considerations.

It must be emphasized that the approach used for addressing specific concrete degradation issues (such as ASR) must be appropriate to the circumstances and the issue(s) being addressed and cannot be generally prescribed in a construction code. The code and commentary can-not replace sound engineering knowledge, experience and judgement . The basic premise in design and construction codes for ASR as well as in the CLB for Seabrook is prevention by controlling the materials used in the concrete mix design at the time of construction. The approach being pursued by the licensee, to a significant extent based on large-scale testing at UT- Austin, is technically the appropriate approach to address structural performance of ASR-affected Seabrook structures for limit states where gaps exist in the ASR literature. This is a superior approach to comprehensively address the issue with regard to structural performance than any guidance in Chapter 20 of ACI 318-71, which in the first place did not consider ASR.

INTENT OF TESTING BEING CONDUCTED

In a public meeting held on April 23, 2012 to discuss the plans and schedule regarding concrete degradation due to ASR, NextEra presented several statements in their slides that provide some insight as to the intent of the testing being conducted at the University of Texas. The following statements indicate that the testing will be used to support resolution of the PODs and

Comment [n9]: I disagree. Chapter 20 as it reads in the 1971 and 2011 revisions is for existing structures and is directly applicable to the current ASR degradation issue. The time frame is indefinite.

Alice: A timeframe is not mentioned in the Code or Commentary so I decided to delete this sentence. *Chapter 20 guidance is generally inappropriate to address ASR because its effects are not well understood, varies with time and has the potential to alter the structural behavior of concrete. Fundamentally, evaluation for ASR degradation effects was not even a consideration in the code.*

Comment [w10]: I do not believe this statement is accurate and it is not supported by later versions of ACI 318, (reference ACI 318-2011 and commentary in Sections 5.6.5/R5.6.5, and 20.1/R20.1. I strongly believe that Chapter 20 of the 1971 revision applies and that 2011 revision and commentary makes it clearer.

Comment [n11]: Should also discuss the other option which is a strength investigation by analysis. This is still not an option until NextEra fully understands the material properties of the concrete in place.

Alice: I briefly described the strength investigation at the beginning of this paragraph. *The conventional material property-based analysis approach is not appropriate for ASR-affected structures. Analytical approaches should model the kinetics of ASR and requires more specialized analysis techniques.*

Comment [w12]: Agree that a load test is not practical. But, this does not mean that Chapter 20 does not apply. The Building Officer has a responsibility to determine (or judge) what may be an appropriate analysis under Chapter 20.

Alice: I don't want to imply that Chapter 20 does not apply. I don't completely agree that the building official has a responsibility to determine what may be an appropriate analysis. If by the same logic that I used to conclude that the NRC is the building official, then the engineer may order a strength evaluation, as stated in the equivalent section of ACI 349, Chapter 20.1. Not the regulatory authority.

to provide some basis for demonstrating that the effects of aging will be adequately managed for license renewal:

- Ongoing full scale testing is expected to validate assumptions and identify additional margin.

- Testing is anticipated to show that the performance of ASR-affected concrete structures is not compromised.

- Design parameters for ASR affected concrete [derived from ASR-affected and control beams] will be compared to ACI Construction Code requirements and reconciled with Seabrook design basis calculations.

- AMP criteria and frequency will be revised as the full-scale concrete beam test program develops.

- Ongoing testing programs are expected to identify additional structural margin.

Based on this information, the staff understands that the testing being conducted at the University of Texas will be used in the final corrective action for resolution of the PODs. However, the details as to how the testing will support the resolution of the PODs remain unclear to the staff. The staff also understands that the testing will no longer serve as a basis for the development of their aging management program; however, the results of the testing may inform certain elements of the program that NextEra is currently proposing.

ASSESSMENT

As was stated earlier, Seabrook Station's UFSAR clearly indicates that the Seismic Category I concrete structures, exclusive of the containment structure, were designed to meet the strength design requirements of ACI 318-71 for load combinations in UFSAR Table 3.8-16. As such, this Code is ~~applicable in that it is~~ the Construction Code-of-Record that forms the current licensing design basis for the Category I structures.

The intent of this paper is to communicate that the strength design provisions of ACI 318-71 must be satisfied in order for Seabrook Station to demonstrate that the ASR-affected concrete structures will perform their intended safety function within the CLB; however, unless proven otherwise, the empirical relationships in the design provisions of the Code should be treated with caution because the code provisions, which include empirical relationships therein, did not consider ASR concrete degradation effects. ~~and should not be relied upon for strength evaluation because those empirical relationships do not account for the effects of ASR.~~ Additionally, because ACI 318-71 does not provide a technical basis for establishing the design adequacy of ASR-affected reinforced concrete structural systems using its strength design provisions, ~~and because NextEra's approach to demonstrating Code compliance is not consistent with the guidance described in Chapter 20 for strength evaluations,~~ the technical basis by which NextEra demonstrates the ability of the ASR-affected structures to perform their intended safety function in compliance with the regulations ~~-~~may require a change to the current licensing basis in the final corrective action resolution of the current PODs. However, it is the licensee's responsibility to make ~~this~~ the determination of whether a license amendment is required by evaluating its proposed ~~approach~~ change in the final corrective action for

Comment [n13]: Add bullets or numbering for the list of 5 intentions.

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Formatted: List Paragraph, Bulleted + Level: 1 + Aligned at: 0.25" + Indent at: 0.5"

Formatted: List Paragraph, Bulleted + Level: 1 + Aligned at: 0.25" + Indent at: 0.5"

Comment [w14]: Substitute "may not"

Alice: Decided not to change because relationships were based on data of normal concrete.

Comment [n15]: The testing that NextEra is doing is outside of the ACI 318-71 code requirements for Chapter 20 and therefore, they must request approval from the building official (aka NRC). This should be explicitly stated. Their plan to perform large-scale model testing to prove strength is not an analysis (as the material properties are not well understood and it's not an exact replica of Seabrook's existing structures) or a load test as described in the code.

Alice: As you stated, the material properties are not well understood. In section 20.1.3, it states "if the effect of the strength deficiency is not well understood or if it is not feasible to establish the required dimensions and material properties by measurement, a load test shall be required…" We already know that the load test is not practicable, therefore, it may be appropriate to pursue and alternate method to show that the structures remain within their design basis. I also note, although I'm not entirely sure how much weight this carries, that the Code states "the Code and Commentary cannot replace sound engineering knowledge, experience, and judgement."

Comment [w16]: I believe we need to be stronger in the language we use in this section/conclusion. Specifically, NextEra is not currently adhering to the methods for evaluating the strength of existing structures in Chapter 20, therefore they are pursuing an approach that is not recognized by ACI 318-71 and are outside their CLB. They will have to seek NRC (Building Official) approval before resolving the ASR issue at Seabrook Station. Accordingly, they proceed at their own risk and without NRC approval of the approach they are taking.

Alice: I decided to delete the discussion for the method of evaluation. I don't believe we have enough information and a clear understanding as to what they are planning to do with the results of that testing *and what a 50.59 evaluation of potential change would look like. A change or potential change in CLB in itself does not necessarily translate to a license amendment.* I don't think we can say the method of evaluation alone is outside the CLB.

establishing the long-term design adequacy of ASR-affected structures ~~with respect to the ACI 318-71 code and~~against the regulatory requirements contained in 10 CFR 50.59 “Changes, tests and experiments.” It is emphasized that, in its application, the code and commentary cannot replace sound engineering knowledge, experience and judgement in order to ensure safety.

At this time, it does not seem necessary to seek clarification from the American Concrete Institute because, as presented in this paper, the staff has a generally agreed upon position and understanding of the ASR issue as it relates to the ACI 318-71 Code requirements.

Buford, Angela

From: Raymond, William NRO
Sent: Tuesday, February 19, 2013 10:09 AM
To: Marshall, Michael; Cook, William; Trapp, James; Sheikh, Abdul; Erickson, Alice; Milano, Patrick; Buford, Angela; Thomas, George; Morey, Dennis; Graves, Herman; Philip, Jacob; Hiser, Allen; Fuhrmann, Mark; Sheehan, Neil
Subject: RE: Heads-Up: Slides for Prep Meeting for Public Meeting with NextEra re Seabrook ASR Open Item

Thanks, Mike. Sorry I missed your meeting – I got tied up 7th floor of TWFN in meetings with NRO staff. The messages look good (and right on). I will be sure to listen in on the actual meeting with NextEra.
Bill

From: Marshall, Michael
Sent: Tuesday, February 19, 2013 7:01 AM
To: Cook, William; Trapp, James; Sheikh, Abdul; Erickson, Alice; Milano, Patrick; Buford, Angela; Thomas, George; Morey, Dennis; Graves, Herman; Philip, Jacob; Hiser, Allen; Fuhrmann, Mark; Sheehan, Neil; Raymond, William
Subject: Heads-Up: Slides for Prep Meeting for Public Meeting with NextEra re Seabrook ASR Open Item

Hello,

If you plan on participating in today's prep meeting for the public meeting with NextEra later this week, please, bring a copy of the attached slides and list of key messages.

Michael L. Marshall, Jr.
Chief
Aging Management of Structures, Electrical, and Systems Branch
Division of License Renewal
Office of Nuclear Reactor Regulation

301-415-2871
Email: michael.marshall@nrc.gov

From: Erickson, Alice NRR
Sent: Tuesday, February 19, 2013 6:54 AM
To: Marshall, Michael
Subject: Public Meeting Slides

Michael,

Attached are Abdul and my current slides for the public meeting on Thursday.

Alice Erickson
General Engineer
Office of Nuclear Reactor Regulation
Division of License Renewal
Aging Management of Structures, Electrical, and Systems Branch

Mail Stop: O-11F1
Phone: (301) 415-1933
Email: Alice.Erickson@nrc.gov

Buford, Angela

From: Raymond, William NRO
Sent: Thursday, February 21, 2013 8:17 AM
To: Sheikh, Abdul; Erickson, Alice
Cc: Conte, Richard; Milano, Patrick; Philip, Jacob; Nicholson, Thomas; Thomas, George; Buford, Angela; Cook, William; Marshall, Michael; Issa, Alfred; Frye, Timothy
Subject: RE: Staff's Presentation Slides
Attachments: SBK - Public Meeting Slides-AErickson ASheikh 02-20-2013 - no talking points.pptx

Abdul,
I have no comment on the slides. They look good and provide a good message.
The staff is correct to list multiple aging effects from ASR – cracking, expansion, & change in material properties.
While NextEra may argue that expansion and changes in MPs are a consequence of cracking, they are separate effects that need to be monitored for impact on structural capacities. As the staff points out, NextEra has yet to demonstrate how visual monitoring of CCI / CW alone will adequately trend MPs and expansions.

Lastly, I have a comment for our discussions with NextEra that would go with the points made on Slide 8 – staff concerns regarding inaccessible areas.
In addition to the points made about buried structures (cable vaults), the DLR and ASR Team has previously pointed out to NextEra a concern about monitoring the impacts of ASR on concrete structures not readily visible, such as the concrete behind the liner around the spent fuel pool and cask pit/transfer canal. It is known that portions of concrete in those areas have been chronically wetted due to SFP/pit leakage and ground water infiltration. NextEra has acknowledged this concern but has yet to provide a solution on how to monitor the area.

Bill

From: Milano, Patrick
Sent: Thursday, February 21, 2013 7:32 AM
To: Philip, Jacob; Nicholson, Thomas; Thomas, George
Cc: Conte, Richard; Raymond, William
Subject: FW: Staff's Presentation Slides

Licensee slides provided by separate email.

R

From: Erickson, Alice NRR
Sent: Wednesday, February 20, 2013 2:37 PM
To: Milano, Patrick
Cc: Sheikh, Abdul; Marshall, Michael
Subject:

R

Pat,

Attached are the latest slides Abdul and I have revised without the talking points.

Alice Erickson
General Engineer
Office of Nuclear Reactor Regulation
Division of License Renewal

894

Aging Management of Structures, Electrical, and Systems Branch

Mail Stop: O-11F1
Phone: (301) 415-1933
Email: Alice.Erickson@nrc.gov

Marshall, Michael

Subject:	NRC Position Paper on NextEra Crack Monitoring Methods - Melanie, Michael, & Angie
Location:	Melanie's office
Start:	Tue 3/5/2013 9:30 AM
End:	Tue 3/5/2013 10:00 AM
Recurrence:	(none)
Meeting Status:	Accepted
Organizer:	DLRCalendar Resource
Required Attendees:	Galloway, Melanie; Marshall, Michael; Buford, Angela

When: Tuesday, March 05, 2013 9:30 AM-10:00 AM (GMT-05:00) Eastern Time (US & Canada).
Where: Melanie's office

Note: The GMT offset above does not reflect daylight saving time adjustments.

~~*~*~*~*~*~*~*~*

B95

Title: Discussion of NRC position paper on Crack Monitoring

Date & Time: Tuesday, March 5, 2013, from 9:30-10:00 AM EST

Location: Melanie's office

Participants: Melanie Galloway, Michael Marshall and Angela Buford

Purpose: To provide clarifying discussion on the following position paper topics:

- Brief background on crack indexing methods and use at Seabrook Station
- Address Melanie's questions:
  - How the paper has been shared with the Region
  - Application of crack indexing position paper to license renewal review
  - Applicability of U of T testing to Seabrook structures, specifically address whether/how test specimens created under lab conditions can compare to field concrete
- Comparison of ASR surface cracking to presence of ASR and level of degradation
- Visual inspection methods' ability to detect out of plane cracking
- Potential effect of ASR on rebar stresses/strains

Outcome: Common understanding of position paper topics and application to license renewal

Process: License renewal review of ASR Monitoring Program

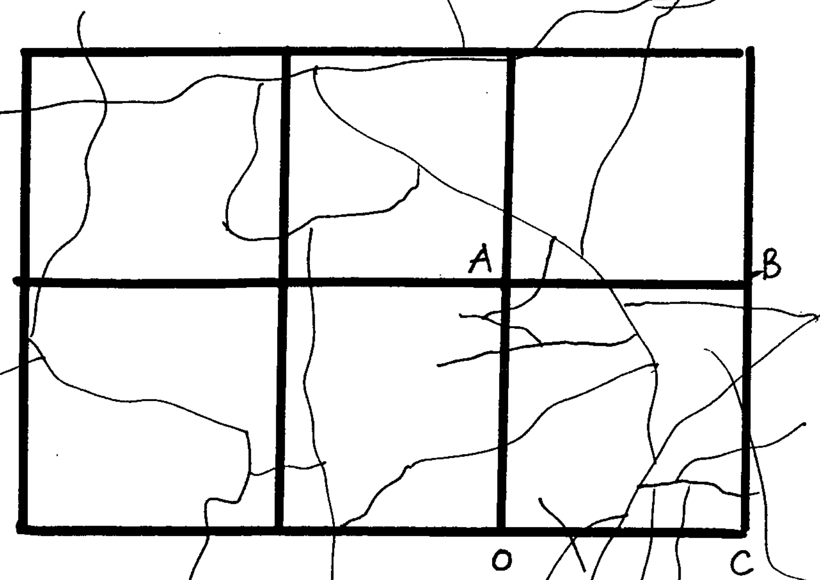
Key Messages:

1. Surface cracking is only "somewhat" related to the overall amount of expansion reached by ASR-affected concrete, and there are many examples that lend uncertainty to the ability to quantify the actual ASR degradation (expansion) occurring in the structure. This is corroborated from our independent review, as well as the licensee's own experts.

2. Crack monitoring and indexing WOULD BE an acceptable way to monitor the concrete for deterioration of strength and durability if for EACH set of similar structures (similar environment and rebar detailing), surface cracking measurements must be correlated to (1) internal ASR degradation through the section, (2) rebar strain, and (3) anticipated strength loss.

CRACK INDEXING

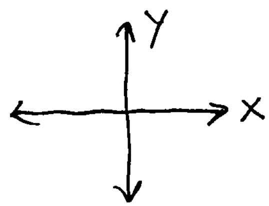
	BASE LENGTH	#CRACKS	TOTAL SUM (mm)	AVG/CRACK	AVG/m	CI mm/m
OA	.5m	4	1.8	.45	3.6	
AB	.5m	2	1.2	.6	2.4	
BC	.5m	5	2.5	.5	5	
CO	.5m	5	2.8	.56	5.6	



AVG. CCI in X direction = 4.3

AVG CCI in Y direction = 4

accuracy of instrument = .05± mm
cracks measured ≥ .1mm



⊖ CONCRETE WALL

February 11, 2013

Memorandum To: ASR Working Group
From: Angela R. Buford
Through: Richard Conte, ASR Project Manager, Region I
Subject: Position Paper: In-situ Monitoring of ASR-affected concrete: A study on crack indexing and damage rating index to assess the severity of ASR and to monitor ASR progression

The purpose of this position paper is to provide the ASR Working Group and inspection team with a basis to assess the adequacy of using crack indexing and damage rating index to determine severity of ASR and monitor its progression of degradation in reinforced concrete structures at Seabrook Station. Further, the paper provides the basis for a recommendation that using the method of combined crack indexing alone to characterize the extent of ASR damage to-date and monitor the progression is not adequate, and that additional measures should be taken to provide a baseline understanding of the ASR affect on structures before combined cracking index can be correlated to anticipated structural performance.

Key Messages:

1. Surface cracking may not be indicative of the conditions of the concrete through the full section of the concrete member, and crack indexing measurements may not consistently indicate the level of ASR severity from one structure to another. For each group of similar (i.e., reinforcement detail, size, environmental conditions) structures, additional examinations are necessary to correlate crack measurements to severity of ASR degradation.

2. Crack mapping results should be correlated to actual strains (and therefore stresses) in the concrete and rebar in order to accurately represent the effect of ASR-induced stresses in engineering evaluations for structural behavior.

3. Damage Rating Index (DRI) is a more accurate measure of ASR severity than crack indexing, and alleviates many of the pitfalls of the crack indexing method. DRI should be considered as a method to assess damage related to ASR. However, since there is no standard on performing the DRI, one would need to be developed to ensure consistency.

Copy to:
William Cook, James Trapp, William Raymond, Suresh Chaudary, Angela Buford, George Thomas

Position Paper: In situ Monitoring of ASR-affected Concrete: A study on crack indexing and damage rating index to assess the severity of ASR and to monitor ASR progression

Recommendation: Using the method of combined crack indexing alone to characterize the extent of ASR damage to-date and monitor the progression is not adequate. Additional measures should be taken to provide an understanding of the ASR affect on structures before combined cracking index can be correlated to anticipated structural performance.

Key Messages:

1. Surface cracking may not be indicative of the conditions of the concrete through the section, and crack indexing measurements may not consistently indicate the level of ASR severity from one structure to another. For each group of similar (i.e., reinforcement detail, size, environmental conditions) structures, additional examinations are necessary to correlate crack measurements to severity of ASR degradation.

2. Crack mapping results should be correlated to actual strains (and therefore stresses) in the concrete and rebar in order to accurately represent the effect of ASR-induced stresses in engineering evaluations for structural behavior.

3. Damage Rating Index (DRI) is a more accurate measure of ASR severity than crack indexing, and alleviates many of the pitfalls of the crack indexing method. DRI should be considered as a method to assess damage related to ASR.

Background:

Alkali-Silica Reaction (ASR)

ASR is a chemical reaction that occurs in concrete between alkali hydroxides dissolved in the concrete pore solution and reactive silica phases in the aggregates. The product of the reaction is an expansive gel around the aggregate particles, which imbibes water from the pore fluid, and, having much larger volume than the reacting components, triggers a progressive damage of the material (Winnicki and Pietruszczak 2008). The pressures imparted by the gel onto the concrete can exceed the tensile strength of the aggregates and the cement paste and cause microcracking and macrocracking in the aggregate and surrounding paste. With the presence of moisture, the gel expands and can cause destructive cracking and deleterious expansion of the concrete. The extent of the concrete deterioration depends on aggregate reactivity, high levels of alkalinity, availability of moisture, temperature, and structural restraint (Williams, Choudhuri, and Perez 2009). Concrete expansion and cracking can lead to serious operational and serviceability problems in concrete structures (Rivard et al. 2002).

Surface Cracking and Expansion

The Federal Highway Administration (FHWA) Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction in Transportation Structures states that "in concrete members undergoing internal expansion due to ASR and subject to wetting and drying cycles (cyclic exposure to sun, rain, wind, etc.), the concrete often shows surface cracking because of induced tension cracking in the 'less expansive' surface layer (because of variable humidity conditions and leaching of alkalis) under the expansive thrust of the inner concrete core (with more constant humidity and pH conditions)." Cracks first form as three or four-pronged star patterns resulting from expansion of the gel reacting with the aggregate. If the concrete is not subject to directional stress, the crack pattern developed forms irregular polygons, commonly referred to as map cracking (Swamy 1992). This cracking is usually enough to relieve the pressure and accommodate the resulting volume increase (Figg 1987; reported by Farny et al. 2007).

Map cracking is one of the most commonly reported visual signs associated with ASR. The pattern and severity of cracking vary depending on the type and quantity of reactive aggregate used, the alkali content of the concrete, exposure conditions, distribution of stresses, and degree of confinement in the concrete (Smaoui et al. 2004). ASR can also be characterized by longitudinal cracking, surface discoloration, aggregate pop-out, and surface deposits (gel or efflorescence) (Williams, Choudhuri, and Perez 2009). Although pattern cracking is a characteristic visual indication that ASR may be present in the concrete, ASR can exist in concrete without indications of pattern cracking. Newman (2003) noted that "while superficial cracking patterns can often be reminiscent of ASR, it is important to be aware that reliable diagnosis can never be adequately based on the appearance of surface cracking alone." This is also emphasized by Hobbs (as reported by Bensted and Barnes, 2001), whose research cites examples where cracking from other mechanisms was diagnosed as ASR, and also examples in which ASR gel and associated cracked aggregate particles were found in concrete that was uncracked. In addition, in ASR-affected structures with reinforcement close to the surface or in heavily reinforced structures, surface cracking may be suppressed while internal damage exists throughout the section. The presence and extent of surface cracking is not a conclusive indication that ASR is present, nor is it a conclusive measure of concrete degradation due to ASR. Conversely, the absence of surface cracking does not conclusively indicate the absence of ASR.

Crack Mapping/Indexing Review

In order to determine the effect of ASR on the performance of a concrete structure, it is important that there be an understanding of current concrete condition (ASR damage reached to-date) and the rate of ASR expansion. Crack indexing is a method that is proposed to measure crack widths and expansion of cracks over time. For this type of visual examination individual crack widths are measured over a defined grid and the total amount of cracking is quantified. The examination is repeated at regular intervals and the results are compared over time, with a goal of establishing a rate of ASR progression. The Institute of Structural Engineers (ISE 1992) proposed a method for crack mapping that consists of measuring the ASR crack widths along five parallel lines that are each 1 m long. Lines are traced directly onto the

concrete structure. The total width of intersecting cracks along each line is summed and divided by the length over which they were measured, to determine the severity of ASR cracking, and then over time to determine the rate of expansion. Another method, suggested by Laboratoire Central des Ponts et Chaussees (LCPC 1997), consists of measuring the widths of all cracks intersecting two perpendicular 1m lines originating from the same point and their two diagonals 1.4 m long. The total crack index is determined as a value in millimeters per meter and compared to criteria that correspond to action levels.

Summary of General Discussion on Crack Mapping

It is stated throughout published ASR research that crack mapping is somewhat limited in its applicability to understanding ASR degradation in concrete. Saint-Pierre et al. (2007) note that compared to other non-destructive methods developed for assessing the damage induced by ASR, the semi-quantitative surface methods like crack mapping appear to be less effective. It is generally agreed that while results of crack indexing can potentially give some indication of how ASR is progressing over time, establishing an absolute trend that directly correlates expansion levels to ASR progression may not be a reliable practice. Much of the published ASR research also indicates that using crack measurement alone to characterize the current state of ASR degradation would not be advised, since the practice relies on the assumption that the surface cracking on the face of a structure is wholly congruent to ASR severity. In the 2010 Addendum to its report titled "Structural Effects of Alkali-Silica Reaction - Technical guidance on the Appraisal of Existing Structures," ISE stated that the crack summation procedures for estimating expansion to date work well in directions where there is little restraint from structural stress, reinforcement, or prestress. This suggests that in structures with higher restraint, this would not be the case. In addition, crack mapping is limited in that it can only give data on two-way crack measurements and does not capture cracking in the out-of-plane direction. It is suggested that further activities be carried out for assessing current condition of the concrete and current expansion rate, as well as correlating the expansion to structural integrity.

In addition, crack indexing evaluation criteria should not be universally applied to all structures because surface cracking may not give a reliable indication of the ASR degradation to the structure. Due to variability in size, location, environment, reinforcement detailing, and relative severity of ASR damage, it may be necessary to obtain an understanding of the ASR effects for each individual structure or group of structures with similar physical properties and environments. Indeed, Newman (2003) stated "it is important to relate cracking patterns variously to structural geometry and/or design, apparent concreting sequence, localized detailing (especially where cracking may be coincident with water leakage) and both environmental and in-service conditions." Deschenes et al. (2009) also state that research into the method highlighted that a number of factors (size and shape of member, restraint present, depth of cover, etc.) leading to poor correlation between crack indexing and measured expansions.

Surface Cracking vs. Internal ASR Damage

The correlation between surface cracking and ASR deterioration may be closer to unity for specimens used in the laboratory that are only allowed to deteriorate due to ASR conditions. However, for concrete in the field, the surface indications sometimes poorly correlate to the extent of ASR degradation within the concrete. Since conditions are so variable from one region to another, and even from one location to another in the same structure, poor correlations are often observed between the severity of surface cracking and the presence of the internal signs of ASR (i.e., reaction products, micro-cracking, and expansion) (Nishibayashi et al. 1989 and Stark 1990 reported by Smaoui et al. 2004). Development of cracking on the surface depends strongly on the amount of reinforcement close to the surface (Smaoui et al. 2002) and also depends on external environmental conditions such as wetting-drying, freezing-thawing, and exposure to saline solutions (Smaoui et al. 2002). Two examples of situations in which external conditions can affect the surface cover concrete such that the surface features are not indicative of the actual ASR degradation of the structure are presented here for consideration. In one case, presence and extent of surface cracking can depend on the pH of the surface which can be affected by leaching and carbonation. As such, wetting-drying cycles can affect the features of ASR, as conditions at the surface layer could be less favorable to the development of ASR, due to the [lower] humidity during the drying periods and the leaching of alkalis during the wetting periods (Poitevin 1983 and Swamy 1995, reported by Smaoui et al. 2004). In other words, if the outer surface layer of concrete is exposed to conditions that would cause the ASR severity or development to be lower, but conditions inside the concrete remain conducive to ASR development (i.e., high relative humidity); surface conditions would not be representative of the ASR within the concrete section. Crack indexing efforts would incorrectly characterize the level of ASR degradation as minor, when within the section the ASR degradation might be more severe.

Another example in which environmental conditions have caused surface conditions to be different than conditions within the concrete is the subject of a study done by Berube et al. (2002). In this study, an attempt was made to correlate ASR expansion with type of exposure to moisture. Results showed that specimens exposed to wetting-drying cycles saw more surface cracking but less actual expansion than specimens that were always exposed to humidity. In this case, the larger amount of surface cracking evident in the specimens exposed to wetting-drying cycles did not show to correlate well to the actual expansion due to ASR, with the ASR expansion being less severe than the cracking would indicate. Conversely, the specimens that showed less surface cracking saw a greater expansion due to ASR, which shows that visual examination of surface cracking alone may not be adequate.

Smaoui et al. (2004) state that although the intensity of surface cracking on ASR-affected concrete in service can help to assess the severity of ASR, quantitative measurement of this intensity [i.e., crack mapping] [could] lead to values that generally underestimate the true expansion attained, except maybe when the surface concrete layer does not suffer any ASR expansion at all. If the concrete surface layer undergoes ASR expansion that is less than that of the inner concrete, according to Smaoui et al. (2004), "the measurement of surface cracking will tend to give expansion values lower than the overall expansion of the concrete element under study." This research indicates that the degree of correlation between surface cracking

and actual ASR expansion or degradation tends to vary with the level of exposure, which means that crack indexing over a number of structures with varying environmental conditions may not conclusively measure the extent or severity of ASR degradation.

ASR-induced Stresses

The ISE (2010) noted that for some structures exposed to ASR, internal damage occurs through the depth [of the section] but visible cracking is suppressed by heavy reinforcement. In reinforced concrete structures, expansion of ASR cracks generates tensile stresses in the reinforcing steel while also causing compressive stresses in the concrete surrounding the rebar (this phenomenon is often likened to prestress in the concrete and noted to temporarily improve structural behavior). According to Smaoui et al., 2004, the most useful information in the structural evaluation of an ASR-affected concrete member is the state of the stresses in the concrete, but more importantly in the steel reinforcement. The ASR-induced stresses increase the structural demand on the steel and concrete, but this new design load has likely not been accounted for in the original design or in further structural evaluations. According to Multon et al. (2005), "assessment models have to take into consideration the property of stresses to modify ASR-induced expansions and their effect on the mechanical response of ASR-damaged structures..." The expansion reached to date, the current rate of expansion, and the potential for future expansion of the concrete are particularly critical pieces of information to determine whether or not the reinforcing steel has reached or will at some point reach its plastic limit, thus creating risk of structural failure (FHWA 2010).

Crack mapping alone to determine ASR effects on the structure does not allow for the consideration of rebar stresses. Visual examination and measurement of crack growth need to be correlated to strain measurements taken of ASR-affected concrete and the reinforcing steel. In similar structures, then, the visual indications of expansion due to ASR can relate to stresses in the concrete and reinforcing steel in order to apply ASR-induced stress as an additional load in structural evaluations. Smaoui et al., 2004 propose that if it is not possible to do a destructive examination (i.e., exposing the rebar or taking deep cores) of the structure in question, "an indirect method is based on the expansion accumulated to date...Assuming that this expansion corresponds to that of the reinforcement steel, the stresses within the reinforcement and the concrete could thus be determined from the modulus of elasticity of the steel and the corresponding sections of the concrete elements under investigation." For determining added stresses in in situ structures, once correlation has been made with respect to size and rebar configuration between the in situ structure and a test specimen, it would be appropriate to use crack mapping as a measure of ASR degradation when introducing the additional ASR-induced stresses on concrete and reinforcing steel in structural evaluations.

Discussion on Applicability of Crack Indexing

This report is not intended to present the position that crack indexing and resulting data should not be part of a structural monitoring program to assess the ongoing effects of ASR in concrete. In fact, crack indexing is recommended by the Federal Highway Administration (FHWA 2010)

"to obtain a quantitative rating of the 'surface' deterioration of the structure as a whole" (it should be noted that in the FHWA document, the word "surface" is emphasized with quotation marks, which implies recognition that crack indexing measurements alone provide information limited only to what is occurring at the concrete surface). NRC staff position is that crack mapping can only be useful once there is an understanding of how the conditions inside the concrete, (i.e., relative humidity, presence and severity of cracking, and added stresses in the concrete, reinforcing detail) correlate to the cracking observed at the surface. The FHWA (2010) document agrees, indicating that to obtain an understanding of the current state of ASR degradation and in order to correlate the surface cracking to the actual effects of ASR-induced expansion on the structure, other investigations of the in-situ structure are necessary. In addition to crack indexing, some FHWA recommendations for transportation structures that can be appropriately applied to nuclear structures include taking stress [strain] measurements in reinforcing steel, obtaining temperature and humidity readings, and performing non-destructive testing such as pulse velocity measurements (the recommendation to use pulse velocity measurements is in agreement with the experimental findings of Saint-Pierre et al. 2007). The Institution of Structural Engineers (ISE 2010) suggests that expansion to date and severity of ASR should be evaluated using examination and testing of cores for changes in modulus of elasticity and development of hysteresis (stiffness deterioration). It is also proposed that strain sensors be used as a method of monitoring ASR progression in order to monitor and quantify out-of-plane expansion.

In addition to provisions for monitoring (or predicting) progression of ASR, it is recommended that each structure or group of similar structures undergo petrographic analysis to determine the current state of ASR damage, in order to provide an accurate baseline from which to understand the current severity level and monitor ASR progression.

Damage Rating Index Review

The damage rating index (DRI) was developed by Grattan-Bellew and Danay in 1992 (Reported by Smaoui et al. 2004) as a method to determine the extent of internal damage in concrete affected by ASR (Rivard et al. 2002). The DRI is a method for quantifying both qualitative and quantitative observations and determining severity of ASR using petrographic analysis of polished sections of concrete. It is based on the recognition of a series of petrographic features that are commonly associated with ASR (Rivard et al. 2002). The DRI accounts for defects observed in the concrete, such as the presence and distribution of reaction products, existence of internal microcracking, and location of microcracking (within the aggregate vs. through the cement paste) by assigning a weighting factor to each and quantifying overall damage. When the factors are normalized to an area of 100 cm^2, the resulting number is the DRI. Rivard et al. (2000) noted that the abundance of individual defects and the overall DRI values increased with regularity with increased ASR expansion. It should be noted that the specimens used by Rivard et al. were comprised of reactive aggregates with different reaction mechanisms, but ASR expansion indeed correlated with DRI measures of ASR severity.

Smaoui et al. (2004) performed damage rating indexing on specimens from five concrete mixes using different reactive aggregates to determine if there was a reliable and accurate correlation between ASR damage determined by DRI and ASR expansion measurements. They noted that there exists a potential error in estimating expansion of ASR concrete in the field and establishing a DRI-expansion relationship with laboratory testing. In some of the lab specimens, relatively similar DRI values were obtained for very different expansion levels for cylinders which had been cast with the same concrete mix (and progressed ASR over time). The tests indicated that expansion levels (of in situ structures compared to laboratory specimens) may not be the best indication of ASR degradation. For example, the presence of air bubbles in the proximity of reactive aggregates [in field concrete] usually has the effect of reducing the expansion due to ASR (Landry 1994, Reported by Smaoui et al. 2004). In other words, air bubbles that exist in the in situ concrete structure could result in a smaller expansion of the structure as concluded under crack mapping activities while more severe ASR damage could be present in the structure because ASR features have "room" to grow inside the existing structure before extensive cracking is notable on the concrete surface. Smaoui et al. (2004) concluded that "for evaluating the expansion attained to date by ASR-affected concrete, it may be necessary to reconsider the relevant defects and their respective weighting factors and take into account a certain number of factors such as the presence or absence of entrained air and preexisting cracks and alteration rims" to assess the severity of ASR in structures. It is notable that the research done by Rivard et al. (2000) showed that DRI correlated well with actual ASR expansion, while subsequent work done by Smaoui et al. (2004) proposed that in some cases lack of gross expansion did not correlate to low ASR degradation, and that air bubbles prevented macro-level expansion even though ASR effects were severe. Crack indexing would not have identified this severe ASR progression since that method only measures expansion of surface cracks,

Rivard et al. noted a possible limitation of the DRI method: that weighting factors assigned to each defect may not universally apply to all types of reactive aggregates (reported by Smaoui et al. 2004) and that weighting factor adjustments may be needed depending on the type of reactive aggregate being examined. In other words, DRI results (and their correlation to concrete expansion) should not be applied universally between concretes with different aggregates (with different types of siliceous materials), However, the FHWA (2010) notes that the DRI method can be useful for quantitative assessment of ASR damage for concretes with the same constituents (i.e., same type of reactive aggregate and cement mix design), and can provide useful relative information when cores are taken and a damage rating developed for each structure by the same experienced technician.

Conclusion/Recommendations

In order for the effects of ASR on concrete to be assessed, the parameters that need to be understood are (1) the amount of cracking inside the concrete, (2) ASR-induced expansion-to-date and rate of expansion, and (3) effects of ASR on concrete and rebar stresses. To understand the affects of ASR on structural behavior, the effects of ASR damage inside the

rebar cage should be applied to engineering analyses or laboratory testing of an equivalent structure for each group of similar structures.

Visual examination of the concrete surface, without any other information about the concrete beneath the surface, is not recommended for either determining the current level of ASR degradation or projecting the future effects of ASR in concrete. Crack indexing would be an adequate and reasonable method of monitoring ASR progression once surface cracking can be correlated to actual ASR degradation, including cracking, expansion, and corresponding stresses (strains) in the concrete and rebar. Laboratory and in-situ testing must be performed to correlate surface cracking with loss of mechanical properties because cracking patterns may vary for different structural geometry and/or design, apparent concreting sequence, localized detailing (especially where cracking may be coincident with water leakage) and both environmental and in-service conditions (Newman et al. 2003).

At a minimum, for each set of structures with the same environmental conditions (e.g. chronically wetted, exposed to freeze-thaw action, constant wetting/drying) and section properties (e.g. wall thickness, rebar layout), an initial petrographic analysis should be done to establish the current state of ASR degradation. The severity of ASR damage on the inside of the structure should be correlated to the surface cracking found on the face of the concrete. The expansion measured by subsequent periodic crack indexing can then be assessed on a structure by structure basis depending on that correlation. Also, depending on the correlation between the surface and interior indications for each set of structures, it may be appropriate to adjust the individual crack width and CCI acceptance criteria for different groups of structures. An added benefit to doing an initial petrographic analysis is that the cores removed from the structure could be studied for subparallel microcracking that would not be detected from crack mapping efforts, which only show cracks on the surface face. This is the minimum effort that should be undertaken to gain at least a more informed understanding, for each set of similar structures (physical attributes and environmental conditions), of the ASR expansion reached to date and rate of expansion. The ability to correlate in situ conditions with laboratory testing would strengthen the reliability of the crack indexing method.

A recommended approach to monitoring ASR progression would be the use of embedded strain gauges and other sensors in the concrete to provide a measure of expansion in the concrete. This would provide the most accurate measure of expansion due to ASR and would provide the benefit of understanding expansion due to cracking in the third direction. The application of strain instrumentation would also be able to quantify strains (stresses) on the rebar and concrete in order to apply the additional demand due to ASR to a structural engineering evaluation. Finally, this method would help to establish a rate of expansion in the concrete, and could provide insights into understanding the ASR degradation mechanism, including relating environmental conditions specific to a structure to the rate of change of ASR progression, in order to characterize the potential and extent of continued degradation over time. The data could also be used in engineering analyses to predict the effects of ASR on structural behavior.

The DRI method has been shown to be an effective method for assessing the damage level of ASR-affected structures. However, due to the limitation of this method in being able to apply weighting factors consistently between various types of aggregates, practical implementation of this method would mean that site-specific criteria for severity ratings and weighting factors for ASR indications may need to be established in accordance with the reactivity of the aggregate used on site. Also, since there is no standard test procedure available and thus the DRI method results could be variable from one petrographer to another, it would be important to ensure quality and consistency in the implementation of the method. If consistency could be ensured through quality of the technician performing the initial examination and subsequent examinations, the DRI would provide a beneficial and useful understanding of current ASR degradation and degradation over time.

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Marshall, Michael

From: Marshall, Michael
Sent: Thursday, March 07, 2013 7:34 AM
To: Erickson, Alice
Subject: RE: Points for OGC to consider in their review of the ACI paper

Hello Alice,

Did a quick read. I will have comments. Please, schedule a time for us to talk on Friday, after 8:30 am. Thanks.

Michael L. Marshall, Jr.
Chief
Aging Management of Structures, Electrical, and Systems Branch
Division of License Renewal
Office of Nuclear Reactor Regulation

301-415-2871
Email: michael.marshall@nrc.gov

From: Erickson, Alice
Sent: Thursday, March 07, 2013 7:29 AM
To: Marshall, Michael
Subject: Points for OGC to consider in their review of the ACI paper

Good morning Michael,

I have drafted two points as listed below for Max to consider in his review of the ACI 318 paper. Please provide me any comments/suggestions.

- The Category 1 structures at Seabrook were designed in accordance with the strength design method of ACI 318-71. This paper provides the view that only those portions of the ACI Code, as described in the UFSAR, are what would be considered part of the licensing basis. Another view would be that the UFSAR implies a commitment to ACI-318 in full; and therefore, any method or approach not consistent with that described in ACI-318 would be outside of the CLB (i.e. their testing at the University of Texas is not consistent with the guidance provided in Chapter 20 of the ACI Code).

- The staff views the "Building Official" as the NRC; however, a legal view on this discussion would be greatly appreciated.

Thanks,

Alice Erickson
General Engineer
Office of Nuclear Reactor Regulation
Division of License Renewal
Aging Management of Structures, Electrical, and Systems Branch

Mail Stop: O-11F1
Phone: (301) 415-1933
Email: Alice.Erickson@nrc.gov

B9/6

Marshall, Michael

From:	Marshall, Michael
Sent:	Friday, March 15, 2013 6:59 AM
To:	Lamb, John; Khanna, Meena
Subject:	Request: regulatory process overview paper

Tracking:	**Recipient**	**Recall**
	Lamb, John	Succeeded: 03/15/2013 7:00 AM
	Khanna, Meena	Failed: 03/15/2013 10:11 AM

Hello Meena or John,

Please, send me a copy of the regulatory process overview paper that was discussed at this week's Seabrook ASR working group meeting.

Thanks,

Michael L. Marshall, Jr.
Chief
Aging Management of Structures, Electrical, and Systems Branch
Division of License Renewal
Office of Nuclear Reactor Regulation

301-415-2871
Email: michael.marshall@nrc.gov

B9-1

Buford, Angela

From: Buford, Angela
Sent: Monday, March 18, 2013 4:46 PM
To: Willoughby, Paul
Subject: RE: Certrec Not Working RE: Uploads to CERTREC

Thank you, it is working now. I think the problem is that my account got migrated so that another licensee could give me access to their portal.

Thanks for the follow up.

From: Willoughby, Paul [Paul.Willoughby@nexteraenergy.com]
Sent: Thursday, March 14, 2013 11:27 AM
To: Buford, Angela
Subject: RE: Certrec Not Working RE: Uploads to CERTREC

Angie

https://ims.certrec.com

Paul

From: Buford, Angela [mailto:Angela.Buford@nrc.gov]
Sent: Thursday, March 14, 2013 8:17 AM
To: Willoughby, Paul
Subject: RE: Certrec Not Working RE: Uploads to CERTREC

Paul, would you be able to send me the link for the certrec site? Maybe I am using the wrong one.

From: Willoughby, Paul [Paul.Willoughby@nexteraenergy.com]
Sent: Wednesday, March 13, 2013 4:01 PM
To: Buford, Angela
Cc: Conte, Richard; Trapp, James
Subject: RE: Certrec Not Working RE: Uploads to CERTREC

Angie

I checked the CERTREC website and you are listed as having access to the ASR inspection.

I did notice that Jim Trapp is not in the system. I need name, e-mail and phone number if he wants access.

Paul

From: Buford, Angela [mailto:Angela.Buford@nrc.gov]
Sent: Tuesday, March 12, 2013 3:09 PM
To: Willoughby, Paul
Cc: Conte, Richard
Subject: Certrec Not Working RE: Uploads to CERTREC

Paul, for some reason I am having difficulty accessing Certrec.

Can you look into whether my access might have timed out for some reason?

From: Willoughby, Paul [Paul.Willoughby@nexteraenergy.com]
Sent: Monday, March 04, 2013 3:45 PM
To: Trapp, James; Conte, Richard; Cook, William; Raymond, William; Buford, Angela
Cc: Noble, Rick; Vassallo, Theodore; Brown, Brian
Subject: Uploads to CERTREC

the proprietary version of the Anchor Test Program along with the white paper providing the explanatory overview have been uploaded to CERTREC

the ASR Training Slides have been uploaded to CERTREC

Marshall, Michael

From: Marshall, Michael
Sent: Tuesday, March 19, 2013 7:59 AM
To: Galloway, Melanie
Subject: RE: Are you sitting in on the Seabrook brief at 8:30 am today? EOM

Will do. I will stop by a few minutes early to highlight a couple of things in the briefing material. I am still going through the material

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From: Galloway, Melanie
Sent: Tuesday, March 19, 2013 7:50 AM
To: Marshall, Michael
Subject: RE: Are you sitting in on the Seabrook brief at 8:30 am today? EOM

Indeed we do for exactly the reasons you state. Thanks.

Since today's brief is only half an hour, I was going to sit in as well. Did you want to come to my office?

From: Marshall, Michael
Sent: Tuesday, March 19, 2013 7:48 AM
To: Galloway, Melanie
Subject: RE: Are you sitting in on the Seabrook brief at 8:30 am today? EOM

Hello Melanie,

Yes. I plan to call in and listen.

The Seabrook ASR Issue Working Group is considering circulating a status update to all the responsible executives instead of scheduling and conducting a brief. I expressed our preference for a briefing, but the majority seemed n favor of circulating a status update. Before calling Rich separately to point out the importance of more active exchange of information, I just want to verify that we do strongly prefer a brief.

Michael

From: Galloway, Melanie
Sent: Tuesday, March 19, 2013 7:10 AM
To: Marshall, Michael
Subject: Are you sitting in on the Seabrook brief at 8:30 am today? EOM

B99

Marshall, Michael

From: Marshall, Michael
Sent: Wednesday, March 20, 2013 1:57 PM
To: Sheikh, Abdul
Subject: RE: Region 1 Position Paper on Seabrook Structural Monitoring Program

Hello Abdul,

The paper is suppose to represent our collective best judgment about the minimum elements that should be included in a SMP to enhance the program sufficiently to detect and manage effects of ASR. The paper should not reflect concerns per se but identify type of actions needed to ensure the functions. Basically read the paper I the light of if you had to design a SMP that needed to detect and manage ASR, what is the minimal actions that would be necessary.

Michael L. Marshall, Jr.
Chief
Aging Management of Structures, Electrical, and Systems Branch
Division of License Renewal
Office of Nuclear Reactor Regulation

301-415-2871
Email: michael.marshall@nrc.gov

From: Sheikh, Abdul
Sent: Wednesday, March 13, 2013 11:45 AM
To: Marshall, Michael
Subject: Region 1 Position Paper on Seabrook Structural Monitoring Program

Region has prepared a position paper on Structures Monitoring Program. I was wondering whether position paper has to reflect DLR concerns. The same AMP has been submitted as a part of the LRA in a RAI response in May 2013.

From:	Buford, Angela
Sent:	Tuesday, March 26, 2013 12:29 PM
To:	Marshall, Michael
Subject:	RE: ACTION: Forward Crack Mapping Visual with Acceptance Criteria to Melanie

Ok, will do.

From: Marshall, Michael
Sent: Tuesday, March 26, 2013 12:28 PM
To: Buford, Angela
Subject: RE: ACTION: Forward Crack Mapping Visual with Acceptance Criteria to Melanie

Angie,

Please, go ahead and send it to Melanie from you. Thanks.

Michael L. Marshall, Jr.
Chief
Aging Management of Structures, Electrical, and Systems Branch
Division of License Renewal
Office of Nuclear Reactor Regulation

301-415-2871
Email: michael.marshall@nrc.gov

From: Buford, Angela
Sent: Tuesday, March 26, 2013 12:23 PM
To: Marshall, Michael
Subject: ACTION: Forward Crack Mapping Visual with Acceptance Criteria to Melanie

Michael,

Please forward this to Melanie, as she requested in today's briefing. I revised the typo on the drawing and attached a copy of Seabrook's acceptance criteria for its ASR monitoring program.

Thanks,

Angela R. Buford | Structural Engineer
Division of License Renewal
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852
t: 301.415.3166
angela.buford@nrc.gov

February 11, 2013

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Memorandum To: ASR Working Group
From: Angela R. Buford
Through: Richard Conte, ASR Project Manager, Region I
Subject: Position Paper: In-situ Monitoring of ASR-affected concrete: A study on crack indexing and damage rating index to assess the severity of ASR and to monitor ASR progression

The purpose of this position paper is to provide the ASR Working Group and inspection team with a basis to assess the adequacy of using crack indexing and damage rating index to determine severity of ASR and monitor its progression of degradation in reinforced concrete structures at Seabrook Station. Further, the paper provides the basis for a recommendation that using the method of combined crack indexing alone to characterize the extent of ASR damage to-date and monitor the progression is not adequate, and that additional measures should be taken to provide a baseline understanding of the ASR affect on structures before combined cracking index can be correlated to anticipated structural performance.

Key Messages:

1. Surface cracking may not be indicative of the conditions of the concrete through the full section of the concrete member, and crack indexing measurements may not consistently indicate the level of ASR severity from one structure to another. For each group of similar (i.e., reinforcement detail, size, environmental conditions) structures, additional examinations are necessary to correlate crack measurements to severity of ASR degradation.

2. Crack mapping results should be correlated to actual strains (and therefore stresses) in the concrete and rebar in order to accurately represent the effect of ASR-induced stresses in engineering evaluations for structural behavior.

3. Damage Rating Index (DRI) is a more accurate measure of ASR severity than crack indexing, and alleviates many of the pitfalls of the crack indexing method. DRI should be considered as a method to assess damage related to ASR. However, since there is no standard on performing the DRI, one would need to be developed to ensure consistency

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Copy to:
James Trapp, William Raymond, Suresh Chaudary, Angela Buford, George Thomas

Position Paper: In situ Monitoring of ASR-affected Concrete: A study on crack indexing and damage rating index to assess the severity of ASR and to monitor ASR progression

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Recommendation: Using the method of combined crack indexing alone to characterize the extent of ASR damage to-date and monitor the progression is not adequate. Additional measures should be taken to provide an understanding of the ASR affect on structures before combined cracking index can be correlated to anticipated structural performance.

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Key Messages:

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1. Surface cracking may not be indicative of the conditions of the concrete through the section, and crack indexing measurements may not consistently indicate the level of ASR severity from one structure to another. For each group of similar (i.e., reinforcement detail, size, environmental conditions) structures, additional examinations are necessary to correlate crack measurements to severity of ASR degradation.

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2. Crack mapping results should be correlated to actual strains (and therefore stresses) in the concrete and rebar in order to accurately represent the effect of ASR-induced stresses in engineering evaluations for structural behavior.

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3. Damage Rating Index (DRI) is a more accurate measure of ASR severity than crack indexing, and alleviates many of the pitfalls of the crack indexing method. DRI should be considered as a method to assess damage related to ASR.

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Alkali-Silica Reaction (ASR)

ASR is a chemical reaction that occurs in concrete between alkali hydroxides dissolved in the concrete pore solution and reactive silica phases in the aggregates. The product of the reaction is an expansive gel around the aggregate particles, which imbibes water from the pore fluid, and, having much larger volume than the reacting components, triggers a progressive damage of the material (Winnicki and Pietruszczak 2008). The pressures imparted by the gel onto the concrete can exceed the tensile strength of the aggregates and the cement paste and cause microcracking and macrocracking in the aggregate and surrounding paste. With the presence of moisture, the gel expands and can cause destructive cracking and deleterious expansion of the concrete. The extent of the concrete deterioration depends on aggregate reactivity, high levels of alkalinity, availability of moisture, temperature, and structural restraint (Williams, Choudhuri, and Perez 2009). Concrete expansion and cracking can lead to serious operational and serviceability problems in concrete structures (Rivard et al. 2002).

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Surface Cracking and Expansion

The Federal Highway Administration (FHWA) Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction in Transportation Structures states that "in concrete members undergoing internal expansion due to ASR and subject to wetting and drying cycles (cyclic exposure to sun, rain, wind, etc.), the concrete often shows surface cracking because of induced tension cracking in the 'less expansive' surface layer (because of variable humidity conditions and leaching of alkalis) under the expansive thrust of the inner concrete core (with more constant humidity and pH conditions)." Cracks first form as three or four-pronged star patterns resulting from expansion of the gel reacting with the aggregate. If the concrete is not subject to directional stress, the crack pattern developed forms irregular polygons, commonly referred to as map cracking (Swamy 1992). This cracking is usually enough to relieve the pressure and accommodate the resulting volume increase (Figg 1987; reported by Farny et al. 2007).

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Map cracking is one of the most commonly reported visual signs associated with ASR. The pattern and severity of cracking vary depending on the type and quantity of reactive aggregate used, the alkali content of the concrete, exposure conditions, distribution of stresses, and degree of confinement in the concrete (Smaoui et al. 2004). ASR can also be characterized by longitudinal cracking, surface discoloration, aggregate pop-out, and surface deposits (gel or efflorescence) (Williams, Choudhuri, and Perez 2009). Although pattern cracking is a characteristic visual indication that ASR may be present in the concrete, ASR can exist in concrete without indications of pattern cracking. Newman (2003) noted that "while superficial cracking patterns can often be reminiscent of ASR, it is important to be aware that reliable diagnosis can never be adequately based on the appearance of surface cracking alone." This is also emphasized by Hobbs (as reported by Bensted and Barnes, 2001), whose research cites examples where cracking from other mechanisms was diagnosed as ASR, and also examples in which ASR gel and associated cracked aggregate particles were found in concrete that was uncracked. In addition, in ASR-affected structures with reinforcement close to the surface or in heavily reinforced structures, surface cracking may be suppressed while internal damage exists throughout the section. The presence and extent of surface cracking is not a conclusive indication that ASR is present, nor is it a conclusive measure of concrete degradation due to ASR. Conversely, the absence of surface cracking does not conclusively indicate the absence of ASR.

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Crack Mapping/Indexing Review

In order to determine the effect of ASR on the performance of a concrete structure, it is important that there be an understanding of current concrete condition (ASR damage reached to-date) and the rate of ASR expansion. Crack indexing is a method that is proposed to measure crack widths and expansion of cracks over time. For this type of visual examination individual crack widths are measured over a defined grid and the total amount of cracking is quantified. The examination is repeated at regular intervals and the results are compared over time, with a goal of establishing a rate of ASR progression. The Institute of Structural Engineers (ISE 1992) proposed a method for crack mapping that consists of measuring the ASR crack widths along five parallel lines that are each 1 m long. Lines are traced directly onto the

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concrete structure. The total width of intersecting cracks along each line is summed and divided by the length over which they were measured, to determine the severity of ASR cracking, and then over time to determine the rate of expansion. Another method, suggested by Laboratoire Central des Ponts et Chaussees (LCPC 1997), consists of measuring the widths of all cracks intersecting two perpendicular 1m lines originating from the same point and their two diagonals 1.4 m long. The total crack index is determined as a value in millimeters per meter and compared to criteria that correspond to action levels.

Summary of General Discussion on Crack Mapping

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It is stated throughout published ASR research that crack mapping is somewhat limited in its applicability to understanding ASR degradation in concrete. Saint-Pierre et al. (2007) note that compared to other non-destructive methods developed for assessing the damage induced by ASR, the semi-quantitative surface methods like crack mapping appear to be less effective. It is generally agreed that while results of crack indexing can potentially give some indication of how ASR is progressing over time, establishing an absolute trend that directly correlates expansion levels to ASR progression may not be a reliable practice. Much of the published ASR research also indicates that using crack measurement alone to characterize the current state of ASR degradation would not be advised, since the practice relies on the assumption that the surface cracking on the face of a structure is wholly congruent to ASR severity. In the 2010 Addendum to its report titled "Structural Effects of Alkali-Silica Reaction - Technical guidance on the Appraisal of Existing Structures," ISE stated that the crack summation procedures for estimating expansion to date work well in directions where there is little restraint from structural stress, reinforcement, or prestress. This suggests that in structures with higher restraint, this would not be the case. In addition, crack mapping is limited in that it can only give data on two-way crack measurements and does not capture cracking in the out-of-plane direction. It is suggested that further activities be carried out for assessing current condition of the concrete and current expansion rate, as well as correlating the expansion to structural integrity.

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In addition, crack indexing evaluation criteria should not be universally applied to all structures because surface cracking may not give a reliable indication of the ASR degradation to the structure. Due to variability in size, location, environment, reinforcement detailing, and relative severity of ASR damage, it may be necessary to obtain an understanding of the ASR effects for each individual structure or group of structures with similar physical properties and environments. Indeed, Newman (2003) stated "it is important to relate cracking patterns variously to structural geometry and/or design, apparent concreting sequence, localized detailing (especially where cracking may be coincident with water leakage) and both environmental and in-service conditions." Deschenes et al. (2009) also state that research into the method highlighted that a number of factors (size and shape of member, restraint present, depth of cover, etc.) leading to poor correlation between crack indexing and measured expansions.

Surface Cracking vs. Internal ASR Damage

The correlation between surface cracking and ASR deterioration may be closer to unity for specimens used in the laboratory that are only allowed to deteriorate due to ASR conditions. However, for concrete in the field, the surface indications sometimes poorly correlate to the extent of ASR degradation within the concrete. Since conditions are so variable from one region to another, and even from one location to another in the same structure, poor correlations are often observed between the severity of surface cracking and the presence of the internal signs of ASR (i.e., reaction products, micro-cracking, and expansion) (Nishibayashi et al. 1989 and Stark 1990 reported by Smaoui et al. 2004). Development of cracking on the surface depends strongly on the amount of reinforcement close to the surface (Smaoui et al. 2002) and also depends on external environmental conditions such as wetting-drying, freezing-thawing, and exposure to saline solutions (Smaoui et al. 2002). Two examples of situations in which external conditions can affect the surface cover concrete such that the surface features are not indicative of the actual ASR degradation of the structure are presented here for consideration. In one case, presence and extent of surface cracking can depend on the pH of the surface which can be affected by leaching and carbonation. As such, wetting-drying cycles can affect the features of ASR, as conditions at the surface layer could be less favorable to the development of ASR, due to the [lower] humidity during the drying periods and the leaching of alkalis during the wetting periods (Poitevin 1983 and Swamy 1995, reported by Smaoui et al. 2004). In other words, if the outer surface layer of concrete is exposed to conditions that would cause the ASR severity or development to be lower, but conditions inside the concrete remain conducive to ASR development (i.e., high relative humidity); surface conditions would not be representative of the ASR within the concrete section. Crack indexing efforts would incorrectly characterize the level of ASR degradation as minor, when within the section the ASR degradation might be more severe.

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Another example in which environmental conditions have caused surface conditions to be different than conditions within the concrete is the subject of a study done by Berube et al. (2002). In this study, an attempt was made to correlate ASR expansion with type of exposure to moisture. Results showed that specimens exposed to wetting-drying cycles saw more surface cracking but less actual expansion than specimens that were always exposed to humidity. In this case, the larger amount of surface cracking evident in the specimens exposed to wetting-drying cycles did not show to correlate well to the actual expansion due to ASR, with the ASR expansion being less severe than the cracking would indicate. Conversely, the specimens that showed less surface cracking saw a greater expansion due to ASR, which shows that visual examination of surface cracking alone may not be adequate.

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Smaoui et al. (2004) state that although the intensity of surface cracking on ASR-affected concrete in service can help to assess the severity of ASR, quantitative measurement of this intensity [i.e., crack mapping] [could] lead to values that generally underestimate the true expansion attained, except maybe when the surface concrete layer does not suffer any ASR expansion at all. If the concrete surface layer undergoes ASR expansion that is less than that of the inner concrete, according to Smaoui et al. (2004), "the measurement of surface cracking will tend to give expansion values lower than the overall expansion of the concrete element under study." This research indicates that the degree of correlation between surface cracking

and actual ASR expansion or degradation tends to vary with the level of exposure, which means that crack indexing over a number of structures with varying environmental conditions may not conclusively measure the extent or severity of ASR degradation.

ASR-induced Stresses

The ISE (2010) noted that for some structures exposed to ASR, internal damage occurs through the depth [of the section] but visible cracking is suppressed by heavy reinforcement. In reinforced concrete structures, expansion of ASR cracks generates tensile stresses in the reinforcing steel while also causing compressive stresses in the concrete surrounding the rebar (this phenomenon is often likened to prestress in the concrete and noted to temporarily improve structural behavior). According to Smaoui et al., 2004, the most useful information in the structural evaluation of an ASR-affected concrete member is the state of the stresses in the concrete, but more importantly in the steel reinforcement. The ASR-induced stresses increase the structural demand on the steel and concrete, but this new design load has likely not been accounted for in the original design or in further structural evaluations. According to Multon et al. (2005), "assessment models have to take into consideration the property of stresses to modify ASR-induced expansions and their effect on the mechanical response of ASR-damaged structures..." The expansion reached to date, the current rate of expansion, and the potential for future expansion of the concrete are particularly critical pieces of information to determine whether or not the reinforcing steel has reached or will at some point reach its plastic limit, thus creating risk of structural failure (FHWA 2010).

Crack mapping alone to determine ASR effects on the structure does not allow for the consideration of rebar stresses. Visual examination and measurement of crack growth need to be correlated to strain measurements taken of ASR-affected concrete and the reinforcing steel. In similar structures, then, the visual indications of expansion due to ASR can relate to stresses in the concrete and reinforcing steel in order to apply ASR-induced stress as an additional load in structural evaluations. Smaoui et al., 2004 propose that if it is not possible to do a destructive examination (i.e., exposing the rebar or taking deep cores) of the structure in question, "an indirect method is based on the expansion accumulated to date...Assuming that this expansion corresponds to that of the reinforcement steel, the stresses within the reinforcement and the concrete could thus be determined from the modulus of elasticity of the steel and the corresponding sections of the concrete elements under investigation." For determining added stresses in in situ structures, once correlation has been made with respect to size and rebar configuration between the in situ structure and a test specimen, it would be appropriate to use crack mapping as a measure of ASR degradation when introducing the additional ASR-induced stresses on concrete and reinforcing steel in structural evaluations.

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Discussion on Applicability of Crack Indexing

This report is not intended to present the position that crack indexing and resulting data should not be part of a structural monitoring program to assess the ongoing effects of ASR in concrete. In fact, crack indexing is recommended by the Federal Highway Administration (FHWA 2010)

"to obtain a quantitative rating of the 'surface' deterioration of the structure as a whole" (it should be noted that in the FHWA document, the word "surface" is emphasized with quotation marks, which implies recognition that crack indexing measurements alone provide information limited only to what is occurring at the concrete surface). NRC staff position is that crack mapping can only be useful once there is an understanding of how the conditions inside the concrete, (i.e., relative humidity, presence and severity of cracking, and added stresses in the concrete, reinforcing detail) correlate to the cracking observed at the surface. The FHWA (2010) document agrees, indicating that to obtain an understanding of the current state of ASR degradation and in order to correlate the surface cracking to the actual effects of ASR-induced expansion on the structure, other investigations of the in-situ structure are necessary. In addition to crack indexing, some FHWA recommendations for transportation structures that can be appropriately applied to nuclear structures include taking stress [strain] measurements in reinforcing steel, obtaining temperature and humidity readings, and performing non-destructive testing such as pulse velocity measurements (the recommendation to use pulse velocity measurements is in agreement with the experimental findings of Saint-Pierre et al. 2007). The Institution of Structural Engineers (ISE 2010) suggests that expansion to date and severity of ASR should be evaluated using examination and testing of cores for changes in modulus of elasticity and development of hysteresis (stiffness deterioration). It is also proposed that strain sensors be used as a method of monitoring ASR progression in order to monitor and quantify out-of-plane expansion.

In addition to provisions for monitoring (or predicting) progression of ASR, it is recommended that each structure or group of similar structures undergo petrographic analysis to determine the current state of ASR damage, in order to provide an accurate baseline from which to understand the current severity level and monitor ASR progression.

Damage Rating Index Review

The damage rating index (DRI) was developed by Grattan-Bellew and Danay in 1992 (Reported by Smaoui et al. 2004) as a method to determine the extent of internal damage in concrete affected by ASR (Rivard et al. 2002). The DRI is a method for quantifying both qualitative and quantitative observations and determining severity of ASR using petrographic analysis of polished sections of concrete. It is based on the recognition of a series of petrographic features that are commonly associated with ASR (Rivard et al. 2002). The DRI accounts for defects observed in the concrete, such as the presence and distribution of reaction products, existence of internal microcracking, and location of microcracking (within the aggregate vs. through the cement paste) by assigning a weighting factor to each and quantifying overall damage. When the factors are normalized to an area of 100 cm^2, the resulting number is the DRI. Rivard et al. (2000) noted that the abundance of individual defects and the overall DRI values increased with regularity with increased ASR expansion. It should be noted that the specimens used by Rivard et al. were comprised of reactive aggregates with different reaction mechanisms, but ASR expansion indeed correlated with DRI measures of ASR severity.

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Smaoui et al. (2004) performed damage rating indexing on specimens from five concrete mixes using different reactive aggregates to determine if there was a reliable and accurate correlation between ASR damage determined by DRI and ASR expansion measurements. They noted that there exists a potential error in estimating expansion of ASR concrete in the field and establishing a DRI-expansion relationship with laboratory testing. In some of the lab specimens, relatively similar DRI values were obtained for very different expansion levels for cylinders which had been cast with the same concrete mix (and progressed ASR over time). The tests indicated that expansion levels (of in situ structures compared to laboratory specimens) may not be the best indication of ASR degradation. For example, the presence of air bubbles in the proximity of reactive aggregates [in field concrete] usually has the effect of reducing the expansion due to ASR (Landry 1994, Reported by Smaoui et al. 2004). In other words, air bubbles that exist in the in situ concrete structure could result in a smaller expansion of the structure as concluded under crack mapping activities while more severe ASR damage could be present in the structure because ASR features have "room" to grow inside the existing structure before extensive cracking is notable on the concrete surface. Smaoui et al. (2004) concluded that "for evaluating the expansion attained to date by ASR-affected concrete, it may be necessary to reconsider the relevant defects and their respective weighting factors and take into account a certain number of factors such as the presence or absence of entrained air and preexisting cracks and alteration rims" to assess the severity of ASR in structures. It is notable that the research done by Rivard et al. (2000) showed that DRI correlated well with actual ASR expansion, while subsequent work done by Smaoui et al. (2004) proposed that in some cases lack of gross expansion did not correlate to low ASR degradation, and that air bubbles prevented macro-level expansion even though ASR effects were severe. Crack indexing would not have identified this severe ASR progression since that method only measures expansion of surface cracks,

Rivard et al. noted a possible limitation of the DRI method: that weighting factors assigned to each defect may not universally apply to all types of reactive aggregates (reported by Smaoui et al. 2004) and that weighting factor adjustments may be needed depending on the type of reactive aggregate being examined. In other words, DRI results (and their correlation to concrete expansion) should not be applied universally between concretes with different aggregates (with different types of siliceous materials), However, the FHWA (2010) notes that the DRI method can be useful for quantitative assessment of ASR damage for concretes with the same constituents (i.e., same type of reactive aggregate and cement mix design), and can provide useful relative information when cores are taken and a damage rating developed for each structure by the same experienced technician.

Conclusion/Recommendations

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In order for the effects of ASR on concrete to be assessed, the parameters that need to be understood are (1) the amount of cracking inside the concrete, (2) ASR-induced expansion-to-date and rate of expansion, and (3) effects of ASR on concrete and rebar stresses. To understand the affects of ASR on structural behavior, the effects of ASR damage inside the

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rebar cage should be applied to engineering analyses or laboratory testing of an equivalent structure for each group of similar structures.

Visual examination of the concrete surface, without any other information about the concrete beneath the surface, is not recommended for either determining the current level of ASR degradation or projecting the future effects of ASR in concrete. Crack indexing would be an adequate and reasonable method of monitoring ASR progression once surface cracking can be correlated to actual ASR degradation, including cracking, expansion, and corresponding stresses (strains) in the concrete and rebar. Laboratory and in-situ testing must be performed to correlate surface cracking with loss of mechanical properties because cracking patterns may vary for different structural geometry and/or design, apparent concreting sequence, localized detailing (especially where cracking may be coincident with water leakage) and both environmental and in-service conditions (Newman et al. 2003).

At a minimum, for each set of structures with the same environmental conditions (e.g. chronically wetted, exposed to freeze-thaw action, constant wetting/drying) and section properties (e.g. wall thickness, rebar layout), an initial petrographic analysis should be done to establish the current state of ASR degradation. The severity of ASR damage on the inside of the structure should be correlated to the surface cracking found on the face of the concrete. The expansion measured by subsequent periodic crack indexing can then be assessed on a structure by structure basis depending on that correlation. Also, depending on the correlation between the surface and interior indications for each set of structures, it may be appropriate to adjust the individual crack width and CCI acceptance criteria for different groups of structures. An added benefit to doing an initial petrographic analysis is that the cores removed from the structure could be studied for subparallel microcracking that would not be detected from crack mapping efforts, which only show cracks on the surface face. This is the minimum effort that should be undertaken to gain at least a more informed understanding, for each set of similar structures (physical attributes and environmental conditions), of the ASR expansion reached to date and rate of expansion. The ability to correlate in situ conditions with laboratory testing would strengthen the reliability of the crack indexing method.

A recommended approach to monitoring ASR progression would be the use of embedded strain gauges and other sensors in the concrete to provide a measure of expansion in the concrete. This would provide the most accurate measure of expansion due to ASR and would provide the benefit of understanding expansion due to cracking in the third direction. The application of strain instrumentation would also be able to quantify strains (stresses) on the rebar and concrete in order to apply the additional demand due to ASR to a structural engineering evaluation. Finally, this method would help to establish a rate of expansion in the concrete, and could provide insights into understanding the ASR degradation mechanism, including relating environmental conditions specific to a structure to the rate of change of ASR progression, in order to characterize the potential and extent of continued degradation over time. The data could also be used in engineering analyses to predict the effects of ASR on structural behavior.

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The DRI method has been shown to be an effective method for assessing the damage level of ASR-affected structures. However, due to the limitation of this method in being able to apply weighting factors consistently between various types of aggregates, practical implementation of this method would mean that site-specific criteria for severity ratings and weighting factors for ASR indications may need to be established in accordance with the reactivity of the aggregate used on site. Also, since there is no standard test procedure available and thus the DRI method results could be variable from one petrographer to another, it would be important to ensure quality and consistency in the implementation of the method. If consistency could be ensured through quality of the technician performing the initial examination and subsequent examinations, the DRI would provide a beneficial and useful understanding of current ASR degradation and degradation over time.

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References

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Marshall, Michael

From: Buford, Angela
Sent: Monday, April 01, 2013 11:05 AM
To: Marshall, Michael
Subject: RESPONSE: In Situ Monitoring of ASR Paper Submittal
Attachments: In-situ_Monitoring_of_ASR_Paper_Final 4-1-13.docx

Follow Up Flag: Follow up
Flag Status: Completed

Categories: Review

Michael,

Attached is the final version of the crack indexing paper, including consideration of/opportunity for comments by the ASR working group.

I think you said you wanted us to enter the submittal of this document into the license renewal work tracking system.

Next steps will be per your direction.

Angie

B102

April 1, 2013

Memorandum To: ASR Working Group
From: Angela R. Buford
Through: James Trapp, Branch Chief, Division of Reactor Safety, Region I
Subject: Position Paper: In-situ Monitoring of ASR-affected concrete: A study on crack indexing and damage rating index to assess the severity of ASR and to monitor ASR progression

The purpose of this position paper is to provide the ASR Working Group and inspection team with a basis to assess the adequacy of using crack indexing and the damage rating index methods to (1) determine severity of ASR and (2) monitor the progression of degradation in reinforced concrete structures at Seabrook Station. Further, the paper provides the basis for a recommendation that using the method of combined crack indexing alone to characterize the extent of ASR damage to-date and monitor the progression is not adequate, and that additional measures should be taken to provide a baseline understanding of the ASR affect on structures before cracking index measurements can be correlated to anticipated structural performance.

Key Messages:

1. Surface cracking may not be indicative of the conditions of the concrete through the full section of the concrete member, and crack indexing measurements may not consistently indicate the level of ASR severity from one structure to another. For each group of similar (i.e., reinforcement detail, size, environmental conditions) structures, additional examinations are necessary to correlate crack measurements to severity of ASR degradation.

2. Crack mapping results should be correlated to actual strains (and therefore stresses) in the concrete and rebar in order to accurately represent the effect of ASR-induced stresses in engineering evaluations for structural behavior.

3. Damage Rating Index (DRI) is a more accurate measure of ASR severity than crack indexing, and alleviates many of the pitfalls of the crack indexing method. DRI should be considered as a method to assess damage related to ASR. However, since there is no standard on performing the DRI, one would need to be developed to ensure consistency.

Copy to:
James Trapp, William Raymond, Suresh Chaudhary, Angela Buford, George Thomas

Position Paper: In situ Monitoring of ASR-affected Concrete: A study on crack indexing and damage rating index to assess the severity of ASR and to monitor ASR progression

Recommendation: Using the method of crack indexing alone to characterize the extent of ASR damage to-date and monitor the progression is not adequate. Additional measures should be taken to provide an understanding of the ASR affect on structures before cracking index can be correlated to anticipated structural performance.

Key Messages:

1. Surface cracking may not be indicative of the conditions of the concrete through the section, and crack indexing measurements may not consistently indicate the level of ASR severity from one structure to another. For each group of similar (i.e., reinforcement detail, size, environmental conditions) structures, additional examinations are necessary to correlate crack measurements to severity of ASR degradation.

2. Crack mapping results should be correlated to actual strains (and therefore stresses) in the concrete and rebar in order to accurately represent the effect of ASR-induced stresses in engineering evaluations for structural behavior.

3. Damage Rating Index (DRI) is a more accurate measure of ASR severity than crack indexing, and alleviates many of the pitfalls of the crack indexing method. DRI should be considered as a method to assess damage related to ASR. However, since there is no standard on performing the DRI, one would need to be developed to ensure consistency.

Background:

Alkali-Silica Reaction (ASR)

ASR is a chemical reaction that occurs in concrete between alkali hydroxides dissolved in the concrete pore solution and reactive silica phases in the aggregates. The product of the reaction is an expansive gel around the aggregate particles, which imbibes water from the pore fluid, and, having much larger volume than the reacting components, triggers a progressive damage of the material (Winnicki and Pietruszczak 2008). The pressures imparted by the gel onto the concrete can exceed the tensile strength of the aggregates and the cement paste and cause microcracking and macrocracking in the aggregate and surrounding paste. With the presence of moisture, the gel expands and can cause destructive cracking and deleterious expansion of the concrete. The extent of the concrete deterioration depends on aggregate reactivity, high levels of alkalinity, availability of moisture, temperature, and structural restraint (Williams, Choudhuri, and Perez 2009). Concrete expansion and cracking can lead to serious operational and serviceability problems in concrete structures (Rivard et al. 2002).

Surface Cracking and Expansion

The Federal Highway Administration (FHWA) Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction in Transportation Structures states that "in concrete members undergoing internal expansion due to ASR and subject to wetting and drying cycles (cyclic exposure to sun, rain, wind, etc.), the concrete often shows surface cracking because of induced tension cracking in the 'less expansive' surface layer (because of variable humidity conditions and leaching of alkalis) under the expansive thrust of the inner concrete core (with more constant humidity and pH conditions)." Cracks first form as three or four-pronged star patterns resulting from expansion of the gel reacting with the aggregate. If the concrete is not subject to directional stress, the crack pattern developed forms irregular polygons, commonly referred to as map cracking (Swamy 1992). This cracking is usually enough to relieve the pressure and accommodate the resulting volume increase (Figg 1987; reported by Farny et al. 2007).

Map cracking is one of the most commonly reported visual signs associated with ASR. The pattern and severity of cracking vary depending on the type and quantity of reactive aggregate used, the alkali content of the concrete, exposure conditions, distribution of stresses, and degree of confinement in the concrete (Smaoui et al. 2004). ASR can also be characterized by longitudinal cracking, surface discoloration, aggregate pop-out, and surface deposits (gel or efflorescence) (Williams, Choudhuri, and Perez 2009). Although pattern cracking is a characteristic visual indication that ASR may be present in the concrete, ASR can exist in concrete without indications of pattern cracking. Newman (2003) noted that "while superficial cracking patterns can often be reminiscent of ASR, it is important to be aware that reliable diagnosis can never be adequately based on the appearance of surface cracking alone." This is also emphasized by Hobbs (as reported by Bensted and Barnes, 2001), whose research cites examples where cracking from other mechanisms was diagnosed as ASR, and also examples in which ASR gel and associated cracked aggregate particles were found in concrete that was uncracked. In addition, in ASR-affected structures with reinforcement close to the surface or in heavily reinforced structures, surface cracking may be suppressed while internal damage exists throughout the section. The presence and extent of surface cracking is not a conclusive indication that ASR is present, nor is it a conclusive measure of concrete degradation due to ASR. Conversely, the absence of surface cracking does not conclusively indicate the absence of ASR.

Crack Mapping/Indexing Review

In order to determine the effect of ASR on the performance of a concrete structure, it is important that there be an understanding of current concrete condition (ASR damage reached to-date) and the rate of ASR expansion. Crack indexing is a method that is proposed to measure crack widths and expansion of cracks over time. For this type of visual examination individual crack widths are measured over a defined grid and the total amount of cracking is quantified. The examination is repeated at regular intervals and the results are compared over time, with a goal of establishing a rate of ASR progression. The Institute of Structural Engineers (ISE 1992) proposed a method for crack mapping that consists of measuring the ASR crack widths along five parallel lines that are each 1 m long. Lines are traced directly onto the

concrete structure. The total width of intersecting cracks along each line is summed and divided by the length over which they were measured, to determine the severity of ASR cracking, and then over time to determine the rate of expansion. Another method, suggested by Laboratoire Central des Ponts et Chaussees (LCPC 1997), consists of measuring the widths of all cracks intersecting two perpendicular 1m lines originating from the same point and their two diagonals 1.4 m long. The total crack index is determined as a value in millimeters per meter and compared to criteria that correspond to action levels.

Summary of General Discussion on Crack Mapping

It is stated throughout published ASR research that crack mapping is somewhat limited in its applicability to understanding ASR degradation in concrete. Saint-Pierre et al. (2007) note that compared to other non-destructive methods developed for assessing the damage induced by ASR, the semi-quantitative surface methods like crack mapping appear to be less effective. It is generally agreed that while results of crack indexing can potentially give some indication of how ASR is progressing over time, establishing an absolute trend that directly correlates expansion levels to ASR progression may not be a reliable practice. Much of the published ASR research also indicates that using crack measurement alone to characterize the current state of ASR degradation would not be advised, since the practice relies on the assumption that the surface cracking on the face of a structure is wholly congruent to ASR severity. In the 2010 Addendum to its report titled "Structural Effects of Alkali-Silica Reaction - Technical guidance on the Appraisal of Existing Structures," ISE stated that the crack summation procedures for estimating expansion to date work well in directions where there is little restraint from structural stress, reinforcement, or prestress. This suggests that in structures with higher restraint, this would not be the case. In addition, crack mapping is limited in that it can only give data on two-way crack measurements and does not capture cracking in the out-of-plane direction. It is suggested that further activities be carried out for assessing current condition of the concrete and current expansion rate, as well as correlating the expansion to structural integrity.

In addition, crack indexing evaluation criteria should not be universally applied to all structures because surface cracking may not give a reliable indication of the ASR degradation to the structure. Due to variability in size, location, environment, reinforcement detailing, and relative severity of ASR damage, it may be necessary to obtain an understanding of the ASR effects for each individual structure or group of structures with similar physical properties and environments. Indeed, Newman (2003) stated "it is important to relate cracking patterns variously to structural geometry and/or design, apparent concreting sequence, localized detailing (especially where cracking may be coincident with water leakage) and both environmental and in-service conditions." Deschenes et al. (2009) also state that research into the method highlighted that a number of factors (size and shape of member, restraint present, depth of cover, etc.) leading to poor correlation between crack indexing and measured expansions.

Surface Cracking vs. Internal ASR Damage

The correlation between surface cracking and ASR deterioration may be closer to unity for specimens used in the laboratory that are only allowed to deteriorate due to ASR conditions. However, for concrete in the field, the surface indications sometimes poorly correlate to the extent of ASR degradation within the concrete. Since conditions are so variable from one region to another, and even from one location to another in the same structure, poor correlations are often observed between the severity of surface cracking and the presence of the internal signs of ASR (i.e., reaction products, micro-cracking, and expansion) (Nishibayashi et al. 1989 and Stark 1990 reported by Smaoui et al. 2004). Development of cracking on the surface depends strongly on the amount of reinforcement close to the surface (Smaoui et al. 2002) and also depends on external environmental conditions such as wetting-drying, freezing-thawing, and exposure to saline solutions (Smaoui et al. 2002). Two examples of situations in which external conditions can affect the surface cover concrete such that the surface features are not indicative of the actual ASR degradation of the structure are presented here for consideration. In one case, presence and extent of surface cracking can depend on the pH of the surface which can be affected by leaching and carbonation. As such, wetting-drying cycles can affect the features of ASR, as conditions at the surface layer could be less favorable to the development of ASR, due to the [lower] humidity during the drying periods and the leaching of alkalis during the wetting periods (Poitevin 1983 and Swamy 1995, reported by Smaoui et al. 2004). In other words, if the outer surface layer of concrete is exposed to conditions that would cause the ASR severity or development to be lower, but conditions inside the concrete remain conducive to ASR development (i.e., high relative humidity); surface conditions would not be representative of the ASR within the concrete section. Crack indexing efforts could incorrectly characterize the level of ASR degradation as minor, when within the section the ASR degradation might be more severe.

Another example in which environmental conditions have caused surface conditions to be different than conditions within the concrete is the subject of a study done by Berube et al. (2002). In this study, an attempt was made to correlate ASR expansion with type of exposure to moisture. Results showed that specimens exposed to wetting-drying cycles saw more surface cracking but less actual expansion than specimens that were always exposed to humidity. In this case, the larger amount of surface cracking evident in the specimens exposed to wetting-drying cycles did not show to correlate well to the actual expansion due to ASR, with the ASR expansion being less severe than the cracking would indicate. Conversely, the specimens that showed less surface cracking saw a greater expansion due to ASR, which shows that visual examination of surface cracking alone may not be adequate.

Smaoui et al. (2004) state that although the intensity of surface cracking on ASR-affected concrete in service can help to assess the severity of ASR, quantitative measurement of this intensity [i.e., crack mapping] [could] lead to values that generally underestimate the true expansion attained, except maybe when the surface concrete layer does not suffer any ASR expansion at all. If the concrete surface layer undergoes ASR expansion that is less than that of the inner concrete, according to Smaoui et al. (2004), "the measurement of surface cracking will tend to give expansion values lower than the overall expansion of the concrete element under study." This research indicates that the degree of correlation between surface cracking

and actual ASR expansion or degradation tends to vary with the level of exposure, which means that crack indexing over a number of structures with varying environmental conditions may not conclusively measure the extent or severity of ASR degradation.

ASR-induced Stresses

The ISE (2010) noted that for some structures exposed to ASR, internal damage occurs through the depth [of the section] but visible cracking is suppressed by heavy reinforcement. In reinforced concrete structures, expansion of ASR cracks generates tensile stresses in the reinforcing steel while also causing compressive stresses in the concrete surrounding the rebar (this phenomenon is often likened to prestress in the concrete and noted to temporarily improve structural behavior). According to Smaoui et al., 2004, the most useful information in the structural evaluation of an ASR-affected concrete member is the state of the stresses in the concrete, but more importantly in the steel reinforcement. The ASR-induced stresses increase the structural demand on the steel and concrete, but this has likely not been accounted for in the original design or in further structural evaluations. According to Multon et al. (2005), "assessment models have to take into consideration the property of stresses to modify ASR-induced expansions and their effect on the mechanical response of ASR-damaged structures..." The expansion reached to date, the current rate of expansion, and the potential for future expansion of the concrete are particularly critical pieces of information to determine whether or not the reinforcing steel has reached or will at some point reach its plastic limit, thus creating risk of structural failure (FHWA 2010).

Crack mapping alone to determine ASR effects on the structure does not allow for the consideration of rebar stresses. Visual examination and measurement of crack growth need to be correlated to strain measurements taken of ASR-affected concrete and the reinforcing steel. In similar structures, then, the visual indications of expansion due to ASR can relate to stresses in the concrete and reinforcing steel in order to apply ASR-induced stress in structural evaluations. Smaoui et al. (2004) propose that if it is not possible to do a destructive examination (i.e., exposing the rebar or taking deep cores) of the structure in question, "an indirect method is based on the expansion accumulated to date...[a]ssuming that this expansion corresponds to that of the reinforcement steel, the stresses within the reinforcement and the concrete could thus be determined from the modulus of elasticity of the steel and the corresponding sections of the concrete elements under investigation." For determining added stresses in in situ structures, once correlation has been made with respect to size and rebar configuration between the in situ structure and a test specimen, it would be appropriate to use crack mapping as a measure of ASR degradation when introducing the additional ASR-induced stresses on concrete and reinforcing steel in structural evaluations.

Discussion on Applicability of Crack Indexing

This report is not intended to present the position that crack indexing and resulting data should not be part of a structural monitoring program to assess the ongoing effects of ASR in concrete. In fact, crack indexing is recommended by the Federal Highway Administration (FHWA 2010)

"to obtain a quantitative rating of the 'surface' deterioration of the structure as a whole" (it should be noted that in the FHWA document, the word "surface" is emphasized with quotation marks, which implies recognition that crack indexing measurements alone provide information limited only to what is occurring at the concrete surface). NRC staff position is that crack mapping can only be useful once there is an understanding of how the conditions inside the concrete, (i.e., relative humidity, presence and severity of cracking, and added stresses in the concrete, reinforcing detail) correlate to the cracking observed at the surface. The FHWA (2010) document agrees, indicating that to obtain an understanding of the current state of ASR degradation and in order to correlate the surface cracking to the actual effects of ASR-induced expansion on the structure, other investigations of the in-situ structure are necessary. In addition to crack indexing, some FHWA recommendations for transportation structures that can be appropriately applied to nuclear structures include taking stress [strain] measurements in reinforcing steel, obtaining temperature and humidity readings, and performing non-destructive testing such as pulse velocity measurements (the recommendation to use pulse velocity measurements is in agreement with the experimental findings of Saint-Pierre et al. 2007). The Institution of Structural Engineers (ISE 2010) suggests that expansion to date and severity of ASR should be evaluated using examination and testing of cores for changes in modulus of elasticity and development of hysteresis (stiffness deterioration). It is also proposed that strain sensors be used as a method of monitoring ASR progression in order to monitor and quantify out-of-plane expansion.

In addition to provisions for monitoring (or predicting) progression of ASR, it is recommended that each structure or group of similar structures undergo petrographic analysis to determine the current state of ASR damage, in order to provide an accurate baseline from which to understand the current severity level and monitor ASR progression.

Damage Rating Index Review

The damage rating index (DRI) was developed by Grattan-Bellew and Danay in 1992 (Reported by Smaoui et al. 2004) as a method to determine the extent of internal damage in concrete affected by ASR (Rivard et al. 2002). The DRI is a method for quantifying both qualitative and quantitative observations and determining severity of ASR using petrographic analysis of polished sections of concrete. It is based on the recognition of a series of petrographic features that are commonly associated with ASR (Rivard et al. 2002). The DRI accounts for defects observed in the concrete, such as the presence and distribution of reaction products, existence of internal microcracking, and location of microcracking (within the aggregate vs. through the cement paste) by assigning a weighting factor to each and quantifying overall damage. When the factors are normalized to an area of 100 cm^2, and the resulting number is the DRI. Rivard et al. (2000) noted that the abundance of individual defects and the overall DRI values increased with regularity with increased ASR expansion. It should be noted that the specimens used by Rivard et al. were comprised of reactive aggregates with different reaction mechanisms, but ASR expansion indeed correlated with DRI measures of ASR severity.

Smaoui et al. (2004) performed damage rating indexing on specimens from five concrete mixes using different reactive aggregates to determine if there was a reliable and accurate correlation between ASR damage determined by DRI and ASR expansion measurements. They noted that there exists a potential error in estimating expansion of ASR concrete in the field and establishing a DRI-expansion relationship with laboratory testing. In some of the lab specimens, relatively similar DRI values were obtained for very different expansion levels for cylinders which had been cast with the same concrete mix (and progressed ASR over time). The tests indicated that expansion levels (of in situ structures compared to laboratory specimens) may not be the best indication of ASR degradation. For example, the presence of air bubbles in the proximity of reactive aggregates [in field concrete] usually has the effect of reducing the expansion due to ASR (Landry 1994, Reported by Smaoui et al. 2004). In other words, air bubbles that exist in the in situ concrete structure could result in a smaller expansion of the structure as concluded under crack mapping activities while more severe ASR damage could be present in the structure because ASR features have "room" to grow inside the existing structure before extensive cracking is notable on the concrete surface. Smaoui et al. (2004) concluded that "for evaluating the expansion attained to date by ASR-affected concrete, it may be necessary to reconsider the relevant defects and their respective weighting factors and take into account a certain number of factors such as the presence or absence of entrained air and preexisting cracks and alteration rims" to assess the severity of ASR in structures. It is notable that the research done by Rivard et al. (2000) showed that DRI correlated well with actual ASR expansion, while subsequent work done by Smaoui et al. (2004) proposed that in some cases lack of gross expansion did not correlate to low ASR degradation, and that air bubbles prevented macro-level expansion even though ASR effects were severe. Crack indexing would not have identified this severe ASR progression since that method only measures expansion of surface cracks.

Rivard et al. noted a possible limitation of the DRI method: that weighting factors assigned to each defect may not universally apply to all types of reactive aggregates (reported by Smaoui et al. 2004) and that weighting factor adjustments may be needed depending on the type of reactive aggregate being examined. In other words, DRI results (and their correlation to concrete expansion) should not be applied universally between concretes with different aggregates (with different types of siliceous materials). However, the FHWA (2010) notes that the DRI method can be useful for quantitative assessment of ASR damage for concretes with the same constituents (i.e., same type of reactive aggregate and cement mix design), and can provide useful relative information when cores are taken and a damage rating developed for each structure by the same experienced technician.

Conclusion/Recommendations

In order for the effects of ASR on concrete to be assessed, the parameters that need to be understood are (1) the amount of cracking inside the concrete, (2) ASR-induced expansion-to-date and rate of expansion, and (3) effects of ASR on concrete and rebar stresses. To understand the affects of ASR on structural behavior, the effects of ASR damage inside the

rebar cage should be applied to engineering analyses or laboratory testing of an equivalent structure for each group of similar structures.

Visual examination of the concrete surface, without any other information about the concrete beneath the surface, is not recommended for either determining the current level of ASR degradation or projecting the future effects of ASR in concrete. Crack indexing would be an adequate and reasonable method of monitoring ASR progression once surface cracking can be correlated to actual ASR degradation, including cracking, expansion, and corresponding stresses (strains) in the concrete and rebar. Laboratory and in-situ testing must be performed to correlate surface cracking with loss of mechanical properties because cracking patterns may vary for different structural geometry and/or design, apparent concreting sequence, localized detailing (especially where cracking may be coincident with water leakage) and both environmental and in-service conditions (Newman et al. 2003).

At a minimum, for each set of structures with the same environmental conditions (e.g. chronically wetted, exposed to freeze-thaw action, constant wetting/drying) and section properties (e.g. wall thickness, rebar layout), an initial petrographic analysis should be done to establish the current state of ASR degradation. The severity of ASR damage on the inside of the structure should be correlated to the surface cracking found on the face of the concrete. The expansion measured by subsequent periodic crack indexing can then be assessed on a structure by structure basis depending on that correlation. Also, depending on the correlation between the surface and interior indications for each set of structures, it may be appropriate to adjust the individual crack width and cracking index acceptance criteria for different groups of structures. An added benefit to doing an initial petrographic analysis is that the cores removed from the structure could be studied for subparallel microcracking that would not be detected from crack mapping efforts, which only show cracks on the surface face. This is the minimum effort that should be undertaken to gain at least a more informed understanding, for each set of similar structures (physical attributes and environmental conditions), of the ASR expansion reached to date and rate of expansion. The ability to correlate in situ conditions with laboratory testing would strengthen the reliability of the crack indexing method.

A recommended approach to monitoring ASR progression would be the use of embedded strain gauges and other sensors in the concrete to provide a measure of expansion in the concrete. This would provide the most accurate measure of expansion due to ASR and would provide the benefit of understanding expansion due to cracking in the third direction. The application of strain instrumentation would also be able to quantify strains (stresses) on the rebar and concrete in order to apply the additional demand due to ASR to a structural engineering evaluation. Finally, this method would help to establish a rate of expansion in the concrete, and could provide insights into understanding the ASR degradation mechanism, including relating environmental conditions specific to a structure to the rate of change of ASR progression, in order to characterize the potential and extent of continued degradation over time. The data could also be used in engineering analyses to predict the effects of ASR on structural behavior.

The DRI method has been shown to be an effective method for assessing the damage level of ASR-affected structures. However, due to the limitation of this method in being able to apply weighting factors consistently between various types of aggregates, practical implementation of this method would mean that site-specific criteria for severity ratings and weighting factors for ASR indications may need to be established in accordance with the reactivity of the aggregate used on site. Also, since there is no standard test procedure available and thus the DRI method results could be variable from one petrographer to another, it would be important to ensure quality and consistency in the implementation of the method. If consistency could be ensured through quality of the technician performing the initial examination and subsequent examinations, the DRI would provide a beneficial and useful understanding of current ASR degradation and degradation over time.

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Report No. FHWA-HIF-09-004, Federal Highway Administration (FHWA) "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction in Transportation Structures," dated January 2010

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Buford, Angela

From: Buford, Angela
Sent: Tuesday, April 09, 2013 8:43 AM
To: Trapp, James
Cc: Cook, William
Subject: Conference Call with NextEra

Hi Jim,

Were you planning to have a conference call with NextEra tomorrow morning? Usually we have that call prior to the ASR working group conference call, so I wanted to make sure either way.

Thanks,

Angela R. Buford | Structural Engineer
Division of License Renewal
Office of Nuclear Reactor Regulation
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B103

Buford, Angela

From: Trapp, James RI
Sent: Friday, April 12, 2013 7:56 AM
To: Marshall, Michael; Cook, William; Buford, Angela; Sheikh, Abdul; Erickson, Alice
Cc: Khanna, Meena; Lamb, John
Subject: RE: Seabrook Update on ASR

They did mention this meeting to us during our last visit. I think they are trying to determine whether they want to suspend their LR effort until the Texas testing is done.

From: Marshall, Michael NRR
Sent: Friday, April 12, 2013 7:43 AM
To: Cook, William; Trapp, James; Buford, Angela; Sheikh, Abdul; Erickson, Alice
Cc: Khanna, Meena; Lamb, John
Subject: FYI: Seabrook Update on ASR

FYI Only. No Action.

From: Morey, Dennis NRR
Sent: Thursday, April 11, 2013 1:25 PM
To: Galloway, Melanie
Cc: Plasse, Richard; Marshall, Michael
Subject: RE: Seabrook Update on ASR

Melanie,

Seabrook is conducting a major working meeting next Tuesday at the site. The meeting will include NextEra engineering, ASR concrete consultants, and retired NRC consultant (Sam Collins). The site engineering director (Jim Connolly) plans to give you a phone call with a status update resulting from the meeting. We expect to have more insight on this meeting next Wednesday.

Thanks,
Dennis Morey

B104

Marshall, Michael

From: Marshall, Michael
Sent: Friday, April 12, 2013 7:53 AM
To: Plasse, Richard
Subject: Heads Up: Seabrook ASR External Website

Hello Rick,

Just in case you are unaware, the NRC has an external website for the ASR issue at Seabrook. The site is maintained by Region 1. We do contribute (via DLR PM) to the site (e.g., meeting notices and summaries).

http://www.nrc.gov/info-finder/reactor/seabrook/concrete-degradation.html#mtgs

Michael L. Marshall, Jr.
Chief
Aging Management of Structures, Electrical, and Systems Branch
Division of License Renewal
Office of Nuclear Reactor Regulation

301-415-2871
Email: michael.marshall@nrc.gov

B105

Marshall, Michael

From: Marshall, Michael
Sent: Friday, April 12, 2013 11:28 AM
To: Trapp, James; Cook, William
Cc: Buford, Angela; Sheikh, Abdul; McMurtray, Anthony
Subject: Heads-Up: Technical Support During the Upcoming Inspection in Texas re Seabrook ASR Issue

Hello Jim and Bill,

Tony McMurtray and I discussed how best to support your need for technical support during the upcoming inspection in Texas. We agreed that my branch would provide the technical support and keep his branch informed. So, in addition to Angie, I plan to have Abdul support the upcoming inspection in Texas.

Both have prior commitments for late April and May that I need to make you aware. Abdul will be unavailable from April 26th thru May 2nd. Angie will be unavailable from April 22nd thru April 26th and from May 13th thru May 24th. We may have some flexibility with Angie's work schedule from May 22nd thru 24th. If their availability in April and May is problematic please contact me to discuss options.

I plan to ask Angie to identify the documentation on Certrec that Abdul should read prior to the inspection. If there is additional information that you would like him to review in preparation for the inspection, please, feel free to contact him directly.

Michael L. Marshall, Jr.
Chief
Aging Management of Structures, Electrical, and Systems Branch
Division of License Renewal
Office of Nuclear Reactor Regulation

301-415-2871
Email: michael.marshall@nrc.gov

B106

Marshall, Michael

From: Marshall, Michael
Sent: Friday, April 12, 2013 3:35 PM
To: Erickson, Alice
Subject: RE: Final - ACI 318 White Paper with OCG Review

Hello Alice,

I placed the paper in the folder listed below on the g drive. I made direct edits to the transmittal memo. I did not have any comments or edits on the paper.

G:\ADRO\DLR\RASB\Special Projects\Alkali-Silica Reaction (Regional Support)\0 Return to Lead

After we get a briefing from Yvonne on document processing within the division, please, submit the document to "typing." Please, include all the branch chiefs on the Seabrook Alkali-Silica Reaction Issue Technical Team and key technical staff in R1, NRR, and RES on the distribution list you provide the AAs. Also, indicate on the Form 665 that the document should be non-public.

Michael L. Marshall, Jr.
Chief
Aging Management of Structures, Electrical, and Systems Branch
Division of License Renewal
Office of Nuclear Reactor Regulation

301-415-2871
Email: michael.marshall@nrc.gov

From: Erickson, Alice
Sent: Monday, April 01, 2013 6:55 AM
To: Marshall, Michael
Subject: Final - ACI 318 White Paper with OCG Review

Michael,

Attached is the final version of the ACI white paper. I have incorporated Jeremy's comments, attached our request that was sent to the mailroom, and Jeremy's email reply to our request.

To summarize:

- OGC has no legal objections to the March 12, 2013 version of this position paper. However, future use of the arguments in this position paper outside of the context of a position paper will require additional OGC review to ensure that the arguments remain non-legally objectionable in their new context.

- Per Reg. Guide 1.187, which endorses NEI-96-07, "[r]eferences that are merely listed in the UFSAR and documents that are not explicitly incorporated by reference are not considered part of the UFSAR." The Seabrook UFSAR relies on portions of ACI-318-71, but does not explicitly incorporate the entire code by reference. Therefore, only the portions of the code relied on in the UFSAR are part of the plant's licensing basis. This is consistent with the Staff's reasoning in the position paper that Seabrook's licensing basis does not require compliance with the provisions of ACI 318-71 with respect to evaluating the performance of ASR-affected other Category I structures.

B107

- OGC agrees with the reasoning in the position paper that the definition of "building official" in ACI 318-71, Section 1.2.3, must mean the NRC with respect to nuclear safety-related concrete structures licensed by the NRC such as the ASR-affected other seismic Category I structures at Seabrook.

Alice Erickson

Structural Engineer
Office of Nuclear Reactor Regulation
Division of License Renewal
Aging Management of Structures, Electrical, and Systems Branch

Mail Stop: O-11F1
Phone: (301) 415-1933
Email: Alice.Erickson@nrc.gov

Buford, Angela

From: Buford, Angela
Sent: Wednesday, April 17, 2013 11:32 AM
To: Marshall, Michael
Subject: Response Requested: Preference for Crack Mapping Memo

Michael,

I created a memo for the crack indexing paper and it is in the LR tracking system to be processed and put into ADAMS as a nonpublic document.

Question 1: I have the memo coming from me to the ASR working group, THRU Jim Trapp. Would you prefer the memo came from you?

Question 2: The format is the same as Bill Cook used, so there is no request tied to the paper or further actions indicated for the paper's use. It is being put into ADAMS as a standalone document. Do you prefer this be treated differently?

Angela R. Buford | Structural Engineer
Division of License Renewal
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852
t: 301.415.3166
angela.buford@nrc.gov

B108

Lamb, John

From:	Meighan, Sean NRR
Sent:	Tuesday, April 23, 2013 8:32 AM
To:	Lamb, John
Cc:	Khanna, Meena
Subject:	RE: question

Johnny, you are the best. Thanks for the quick turn around on this Eric question. Put this one in the 'completed' column.

Very Respectfully
Sean

-----Original Message-----
From: Lamb, John NRR
Sent: Tuesday, April 23, 2013 8:26 AM
To: Meighan, Sean
Subject: RE: question

PLANTS AFFECTED BY ASR

(1) Chin Shan Nuclear Power Station (Taiwan)
(2) Tihange-2 (Belgium)
(3) Gentilly-2 (Canada)
(4) Japanese plant (I do not remember the name)
(5) Seabrook (USA)

From: Meighan, Sean
Sent: Monday, April 22, 2013 4:07 PM
To: Lamb, John
Subject: question

John:

ASR,,, are there any other plants other than Seabrook that are currently experiencing this?

Very Respectfully

Sean C. Meighan
Technical Assistant
Nuclear Reactor Regulation
Division of Operating Reactor Licensing
U.S. Nuclear Regulatory Commission
301-415-1020
[cid:image003.jpg@01CE3F73.7A5A24C0]

B109

Lamb, John

From: Lamb, John (NRR)
Sent: Monday, April 29, 2013 1:22 PM
To: Whited, Jeffrey
Cc: Khanna, Meena
Subject: RE: ACTION: CNS Report -- REQUEST FOR CONCURRENCE

Jeff,

I reviewed the Seabrook ASR section in the CNS Report. It is still good and does not need to be changed. You have my concurrence.

Thanks.
John

From: Whited, Jeffrey (NRR)
Sent: Tuesday, April 23, 2013 1:26 PM
To: Lamb, John
Subject: RE: ACTION: CNS Report -- REQUEST FOR CONCURRENCE

If you scroll down to the bottom of the e-mail it has a link to the CNS Report.

From: Lamb, John
Sent: Tuesday, April 23, 2013 1:25 PM
To: Whited, Jeffrey
Subject: RE: ACTION: CNS Report -- REQUEST FOR CONCURRENCE

Where is the Report?

From: Whited, Jeffrey
Sent: Tuesday, April 23, 2013 1:04 PM
To: DiFrancesco, Nicholas; Wilkins, Lynnea; Lamb, John; Poole, Justin; Feintuch, Karl; Gratton, Christopher
Cc: Meighan, Sean
Subject: FW: ACTION: CNS Report -- REQUEST FOR CONCURRENCE
Importance: High

Good Afternoon,

Please see the e-mail below indicating that our review is requested on the draft Convention on Nuclear Safety Report.

Here are the sections that DORL is responsible for, and who is responsible for reviewing the individual sections.

Power Uprate Program (page 19) – Nick DiFrancesco
Plant re-start (page 53) – Lynnea Wilkins
Concrete Degradation (page 42) – John Lamb
Section 6.2 (page 62) – Justin Poole [Kewaunee-Karl Feintuch] [Crystal River-Chris Gratton]
Section 14.1.3 (page 150) – Nick DiFrancesco
Section 14.1.3.1 (page 151) – Nick DiFrancesco
Section 14.1.3.2 (page 152) – Nick DiFrancesco

B/10

Section 18.1.2 (page 200) – Justin Poole

Please review the section that your name is by and provide me any comments (I think copying a section from the document and pasting and editing in an e-mail might be easiest) by **COB Thursday, April 25**. I'm sorry for the short turn around.

I based who reviews what section on e-mails and tables that I got from Sean. If you feel your name is next to a section incorrectly, please let me know and I will solve the issue.

Once I have all of your comments I will send them to the appropriate people to get them incorporated.

Please see the e-mail below for the Link to the Report and the TAC to charge time spent on this to.

Let me know if you have any questions.

Thanks in advance for your help.

Jeff Whited
PM-Susquehanna
NRR/DORL/LPL I-2
O8-D9, 301-415-4090

From: Rodriguez, Veronica
Sent: Monday, April 22, 2013 5:55 PM
To: Albert, Michelle; Audrain, Margaret; Casey, Lauren; Clark, Lisa; Coleman, Nicole; Conley, Maureen; Cool, Donald; Culp, Lisa; Davis, Kristin; Decker, David; Henderson, Karen; Jackson, Christopher; Jefferson, Steven; Love-Blair, Angella; Mahoney, Michael; Meighan, Sean; Mroz, Sara; Norton, Charles; Perin, Vanice; Peterson, Gordon; Poole, Brooke; Reckley, William; Rosales-Cooper, Cindy; Santos, Cayetano; Simpson, JoAnn; Smith, Shawn; Somerville, Glenda; Suttenberg, Jeremy; Swain, Patricia; Tate, Travis; Vechioli, Lucieann; Whited, Jeffrey; Williams, Donna; Wong, Albert; Yip, Brian
Cc: Quinones, Lauren; Carpenter, Gene; Hopkins, Jon
Subject: ACTION: CNS Report -- REQUEST FOR CONCURRENCE
Importance: High

Good Evening Everyone,

As promised, the draft CNS report is included below for your review (*see link*). A memo will be sent to your Directors and their Rids Boxes requesting concurrence. The hard copies of the concurrence memo will also be delivered tomorrow.

Some notes:

- The document is clean and not marked with redline strikeout. The report has gone through a lot of updates (including those from the tech editors) and reading the redline strikeout is *extremely challenging* at this stage. Thus, to facilitate your review, all the changes have been cleared out.
- You can review and comment on the entire report if you wish. I recognize that most of you won't be doing this. However, I strongly encourage you to review the sections for which you provided input (as a primary or secondary reviewer) to ensure everything is in order.
- I will not be delivering hard copies of the report since it has over 300 pages. I'll appreciate if you can print your own copy. If you think this is too burdensome, please feel free to send me an email and I'll accommodate your request.
- Please coordinate the review of the document within your Office or Division and provide comments to me to ensure they get incorporated ASAP. Note that the concurrence is due on **May 3**.

Last but not least, please charge your time to **MD9650/00900/001**

If you have questions, please don't hesitate to contact me or Lauren.
Thanks,
Veronica

CNS Report
CNS Report Concurrence Sheet

Buford, Angela

From: Floyd, Niklas
Sent: Tuesday, April 30, 2013 9:08 AM
To: Raymond, William; Trapp, James
Cc: Cook, William; Sheikh, Abdul; Buford, Angela; Lamb, John; Issa, Alfred; Frye, Timothy
Subject: RE: Seabrook's ASR follow-up

I agree with everything that Bill is saying. I think it's also important to at least discuss the fact that NextEra is utilizing a structural performance approach versus materials property testing. There still seems to be a gap in understanding on this particular topic.

Nik

From: Raymond, William
Sent: Tuesday, April 30, 2013 9:04 AM
To: Trapp, James
Cc: Cook, William; Floyd, Niklas; Sheikh, Abdul; Buford, Angela; Lamb, John; Issa, Alfred; Frye, Timothy
Subject: RE: Seabrook's ASR follow-up

Jim,
Paul Brown's critique of the Interim Assessment is well written and touches on several issues NRC staff have considered regarding the role structural confinement on ASR impacts.
Brown's assertion that the effects of confinement are not supported in the open literature may not reflect a full appreciation of the references in the Interim Assessment and some of the sub-tiered references developed in support of Bayrak's white paper. The questions regarding the adequacy of 2-D crack indexing relative to monitoring structural degradation and performance in the absence of material properties from cores are important - the NRC staff should consider them thoroughly before stating the agency position. During the most recent onsite inspection, the ASR Team raised similar questions regarding how NextEra's crack indexing method differs from industry literature (FHWA) and on the adequacy of measurements in 2D only. The DLR position paper on the SMP (Angie's work) should help inform our response. We might do well to develop a written response (Q&A format) to some of Brown's key points in preparation for the telecom. These are just my initial impressions.
Let me know how I might help.
Bill

From: Trapp, James
Sent: Tuesday, April 30, 2013 7:11 AM
To: Cook, William; Floyd, Niklas; Raymond, William; Sheikh, Abdul; Buford, Angela; Lamb, John
Subject: FW: Seabrook's ASR follow-up

If I missed anyone, please pass this along to potentially interested parties. Thanks

I am willing to provide the results of the mortar bar testing (they were in the last inspection report), not sure where the "release" came from.

I did suggest we talk directly with their expert – since the middle person communication was not very efficient.

Adul – C-10 was very complementary of your knowledge in this area, so I may tap you to participate in this call.

B

Thanks to all for your continued support of the ASR Task Force.

From: Debbie Grinnell [mailto:debbie@c-10.org]
Sent: Monday, April 29, 2013 1:48 PM
To: Debbie Grinnell; Trapp, James
Cc: 'Sandra Gavutis'; Sean Meyer; Paul Brown
Subject: Re: Seabrook's ASR follow-up

Hello Jim,

I appreciated your call last Friday on route to Pilgrim and willingness to provide us with the test values from Seabrook's Mortar Bar Testing. We are encouraged by your stated willingness to release Seabrook's ASR test results for expert review. As I expressed, in 2010 NRC reports included actual data results, but since the NRC has not reported ASR test data results with values in publicly released documentation. I have shared with UCS and our expert that you are as the SAITT team reviewing all test data and the selection and location of samples taken. I have discussed your interest to consult directly with our expert with UCS's Sean Meyer and our expert, Paul Brown, on a conference call. Both have agreed that I can send to you Paul's contact information.

Please feel free to contact Paul Brown via his e-mail grtbrown@aol.com or via phone @ 949-769-1102.

Please find attached Paul Brown's latest commentary requested bu UCS and C-10 on "Seabrook Station: Impact of Alkali-Silica Reaction on Concrete Structures and Attachments" for your SAITT charter review.

My Best,

Debbie

Debbie Grinnell
Research Manager
C-10 Foundation
44 Merrimac Street
Newburyport, Ma. 01950
Tel. 978-465-6646

----- Original Message -----
From: Debbie Grinnell
To: james.trapp@nrc.gov
Sent: Tuesday, April 16, 2013 1:57 PM
Subject: Seabrook's ASR follow-up

Hello Jim,

In NextEra's Response to Confirmatory Action Letter (SBK-L-13027) they state: " In reference 2, the NextEra Energy Seabrook requested deletion of CAL action 7, as the results of the Mortar Bar Expansion Testing obviated the need for long-term expansion testing."

As we discussed, our expert recommended a Prism Test which the NRC also required to be done. Could you provide us the results of the Mortar Bar Expansion test and the rational from NextEra as to why it is now considered unnecessary.

I also asked you, Jim, for the # lb/y3 of alkali present.

Also, where are the test results from Seabrook's ASR affected walls and basemat intheir CEVA and containment areas submerged in 6 feet of water since construction. Whatre the core results? Do we have results from sections on the interior and exterior surface above grade and from sections below grade to compare affected to unaffected areas in the same areas of containment?

Marshall, Michael

From: Pope, Lisa
Sent: Wednesday, May 08, 2013 7:35 AM
To: Khanna, Meena; Marshall, Michael; Kobetz, Timothy; McMurtray, Anthony; Lamb, John; Plasse, Richard; Sheikh, Abdul; Erickson, Alice; Raymond, William; Hogan, Rosemary; Schroeder, Daniel; Dentel, Glenn; Chaudhary, Suresh; Floyd, Niklas; Philip, Jacob; Graves, Herman; Fuhrmann, Mark; Ott, William
Cc: Buford, Angela
Subject: POSITION PAPER: IN SITU MONITORING OF ALKALI-SILICA

Date: April 30, 2013

Letter To: James M. Trapp, BC, R-I, DRS, EB1

From: Angela R. Buford, PM, RASB, DLR

Subject: POSITION PAPER: IN SITU MONITORING OF ALKALI-SILICA REACTION (ASR) AFFECTED CONCRETE: A STUDY ON CRACK INDEXING AND DAMAGE RATING INDEX TO ASSESS THE SEVERITY OF ASR AND TO MONITOR ASR PROGRESSION

View ADAMS P8 Properties ML13108A047
Open ADAMS P8 Document (POSITION PAPER: IN-SITU MONITORING OF ALKALI-SILICA REACTION (ASR) AFFECTED CONCRETE: A STUDY ON CRACK INDEXING AND DAMAGE RATING INDEX TO ASSESS THE SEVERITY OF ASR AND TO MONITOR ASR PROGRESSION)

Lisa M. Pope
U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Division of License Renewal
11555 Rockville Pike, Rockville, MD 20852
Location: O-11A07 / Mail Stop: 11F1
Office: 301-415-8707
E-mail: lisa.pope@nrc.gov

B112

Buford, Angela

From: Buford, Angela
Sent: Thursday, May 23, 2013 4:36 PM
To: Cook, William
Subject: RE: Update

Hi Bill,

Thanks for the update! I'll give you a call next week. Also, I saw Paul Willoughby uploaded the SMP to certrec, so I also plan on looking at that next week when I'm back in the office.

Angie

From: Cook, William
Sent: Thursday, May 23, 2013 12:36 PM
To: Buford, Angela
Subject: Update

Angie,
Received your voicemail. Sorry we missed one another. Abdul's participation was good. I think we made some good progress in understanding the testing program, what the results represent and where NextEra (UT-A and MPR) is going with the test results. We don't see any major snags in bringing the CAL items to closure at this point, but still don't have NextEra's plan for how they are going to address the ASR in the containment structure. Rick Noble indicated they would have plan to share with us in a week or two.
Will keep you posted.
Bill

B1:3

Lamb, John

From: (b)(6) Trapp, James
Sent: Monday, June 03, 2013 9:44 AM
To: Debbie Grinnell
Subject: Seabrook ASR Issue

Good Morning: John Lamb informed me that your left him a voice mail asking if we had reviewed the latest info/submittal from Seabrook regarding concrete degradation. I wanted to let you know that we have and our observations and findings will be documented in our inspection report that should be issued mid-summer.

We are also in the process of getting the redacted versions of the documents onto the Seabrook ASR website.

We appreciate your interest.

B/119

From: Erickson, Alice
To: Sheikh, Abdul
Subject: Call into ASR Status Call Tomorrow if Available
Date: Tuesday, June 04, 2013 3:26:00 PM

Abdul,

I forgot to mention that Michael requested we call into the ASR Working Group meeting tomorrow.

Alice Erickson
Structural Engineer
Office of Nuclear Reactor Regulation
Division of License Renewal
Aging Management of Structures, Electrical, and Systems Branch

Mail Stop: O-11F1
Phone: (301) 415-1933
Email: Alice.Erickson@nrc.gov

B115

Marshall, Michael

From: McMurtray, Anthony
Sent: Thursday, June 06, 2013 4:33 PM
To: Rodriguez, Veronica; Marshall, Michael
Subject: Follow-up Discussion Between NRR Branches Regarding Next Steps for Seabrook ASR Activities

Based on a discussion today between the Seabrook DORL Acting Branch Chief (V. Rodriguez), the cognizant DLR Branch Chief (M. Marshall) and me, the following next steps were decided:

- DE will not send anyone to the University of Texas-Austin testing facility to observe ASR structural testing. DE plans to review the results of this testing if they are submitted as part of a future license amendment request (LAR). DLR may send a reviewer to Texas one time in the future to observe the testing in support of the Seabrook license renewal request that is currently being reviewed by the NRC.

- We decided that if there is a need for future Working Group meetings that Region 1 should remain in the lead of the Working Group. This was due to the fact that there is currently no request associated with the current license and the Seabrook ASR issue being reviewed by NRR. The only request currently being reviewed by NRR is the license renewal that DLR is working. The Seabrook ASR Working Group was initially founded to address any current license (10 CFR Part 50) issues. Any future activities, until a possible current license LAR is submitted, will involve inspection and public outreach which are generally activities led by the region.

Tony McMurtray
Chief, Mechanical & Civil Engineering Branch (EMCB)
Division of Engineering (DE)
Office of Nuclear Reactor Regulation
(301) 415-2746

3/0

Marshall, Michael

From: Marshall, Michael
Sent: Friday, June 07, 2013 10:42 AM
To: Pelton, David
Subject: FYI: Follow-up Discussion Between NRR Branches Regarding Next Steps for Seabrook ASR Activities

FYI only. No action or assistance needed.

Hello Dave,

The three headquarters branch chiefs most involved in the Seabrook ASR issue met yesterday to discuss the proposal our regional counterparts suggested for closing the CAL and providing regulatory oversight after the closure of the CAL. Tony's email below is little stronger and more specific than I would prefer, but it is consistent with our discussion. Our regional counterparts' proposal is to (1) close the CAL in July after verifying all the actions listed in the CAL have been completed, (2) maintain oversight thru periodic PI&R inspections, (3) transition from inspection "space" to licensing "space," (4) under the auspices of licensing conduct periodic visit to the applicant/licensee's test, and (5) transition lead for the working group form this issue from Region 1 to NRR (i.e., DE or DORL).

- We agree with closing the CAL (or do not oppose).
- We believe Region 1 should maintain lead of the Working group until a licensing action is submitted, because the applicant is still conducting work to confirm the operability determination and nonconformance.
- We believe NRC oversight of the Seabrook ASR issue should be under oversight until a licensing action is submitted or issue is truly resolved, because the applicant is still conducting work to confirm the operability determination and nonconformance.
- We do not believe it is appropriate to unilateral open a pre-submittal TAC for a licensing action that is not likely to be submitted until sometime in CY2015.
- We do not believe it would be appropriate to charge activities to license renewal application that go beyond what is needed to make a license renewal finding.

Veronica has lead for setting up a meeting with our two counterparts in Region 1 and the responsible team lead to discuss our feedback on their proposal next week. Additionally, we would share with the region that periodic trips to observe the applicant/licensee's tests would not be needed for licensing purpose. Separately, I believe:

- The working group should be maintained until the issue is resolved. In addition to coordinating the allocation of resources and assignments across offices, the working group has been an effective means of coordinating communication with the public and licensee.

As I mentioned during our meeting this week, the NRC is handling this issue appropriately and at the appropriate pace given our engineers judgment on the possible impact o ASR on the functions of the structures within this time frame. The applicant/licensee has work to do to demonstrate for the remainder of the plants license and any possible renewal that ASR progression will not impair the function of the structures.

Best Regards,
Michael L. Marshall, Jr.
Chief
Aging Management of Structures, Electrical, and Systems Branch
Division of License Renewal
Office of Nuclear Reactor Regulation

301-415-2871
Email: michael.marshall@nrc.gov

From: McMurtray, Anthony
Sent: Thursday, June 06, 2013 4:33 PM
To: Rodriguez, Veronica; Marshall, Michael
Subject: Follow-up Discussion Between NRR Branches Regarding Next Steps for Seabrook ASR Activities

Based on a discussion today between the Seabrook DORL Acting Branch Chief (V. Rodriguez), the cognizant DLR Branch Chief (M. Marshall) and me, the following next steps were decided:

- DE will not send anyone to the University of Texas-Austin testing facility to observe ASR structural testing. DE plans to review the results of this testing if they are submitted as part of a future license amendment request (LAR). DLR may send a reviewer to Texas one time in the future to observe the testing in support of the Seabrook license renewal request that is currently being reviewed by the NRC.

- We decided that if there is a need for future Working Group meetings that Region 1 should remain in the lead of the Working Group. This was due to the fact that there is currently no request associated with the current license and the Seabrook ASR issue being reviewed by NRR. The only request currently being reviewed by NRR is the license renewal that DLR is working. The Seabrook ASR Working Group was initially founded to address any current license (10 CFR Part 50) issues. Any future activities, until a possible current license LAR is submitted, will involve inspection and public outreach which are generally activities led by the region.

Tony McMurtray
Chief, Mechanical & Civil Engineering Branch (EMCB)
Division of Engineering (DE)
Office of Nuclear Reactor Regulation
(301) 415-2746

Marshall, Michael

From: Marshall, Michael
Sent: Monday, June 10, 2013 7:57 AM
To: Trapp, James
Subject: RE: Seabrook ASR

Tony, Veronica, and I met on Thursday. Veronica was planning on arranging a follow-up meeting between us this week. We were planning on pushing back on switching lead from R1 to HQ, and share our view of how licensing and/or pre-submittal activities would be handled. However, from brief email exchange on Friday, it appears we need to touch base with our execs to ensure they are aligned with our position.

From: Trapp, James
Sent: Monday, June 10, 2013 7:43 AM
To: Rodriguez, Veronica; Modes, Michael; Marshall, Michael
Cc: Floyd, Niklas; Cook, William
Subject: Seabrook ASR

I was wondering if you folks had a chance to discuss our going forward ideas with your management? And if so, any outcomes to share? Thanks

8118

Marshall, Michael

From: Marshall, Michael
Sent: Monday, June 10, 2013 8:09 AM
To: Pelton, David
Subject: FW: Follow-up Discussion Between NRR Branches Regarding Next Steps for Seabrook ASR Activities

---

From: McMurtray, Anthony
Sent: Friday, June 07, 2013 1:42 PM
To: Cheok, Michael; Lubinski, John
Cc: Rodriguez, Veronica; Marshall, Michael
Subject: FW: Follow-up Discussion Between NRR Branches Regarding Next Steps for Seabrook ASR Activities

John and Mike,

Mike Marshall, Veronica Rodriguez, and I had a meeting on Thursday afternoon and discussed future activities regarding the Seabrook ASR issue, including continuance of the Seabrook ASR Working Group. The two decisions we reached are noted below: After discussing this further with Mike Cheok, I understand that Mike Cheok and you may have reached a different decision on future NRR support of the Working Group. Please review the e-mail below, discuss with Mike Marshall and let us know what your thoughts are regarding the decisions noted in the e-mail.

Thanks,

Tony

From: McMurtray, Anthony
Sent: Thursday, June 06, 2013 4:33 PM
To: Rodriguez, Veronica; Marshall, Michael
Subject: Follow-up Discussion Between NRR Branches Regarding Next Steps for Seabrook ASR Activities

Based on a discussion today between the Seabrook DORL Acting Branch Chief (V. Rodriguez), the cognizant DLR Branch Chief (M. Marshall) and me, the following next steps were decided:

- DE will not send anyone to the University of Texas-Austin testing facility to observe ASR structural testing. DE plans to review the results of this testing if they are submitted as part of a future license amendment request (LAR). DLR may send a reviewer to Texas one time in the future to observe the testing in support of the Seabrook license renewal request that is currently being reviewed by the NRC.

- We decided that if there is a need for future Working Group meetings that Region 1 should remain in the lead of the Working Group. This was due to the fact that there is currently no request associated with the current license and the Seabrook ASR issue being reviewed by NRR. The only request currently being reviewed by NRR is the license renewal that DLR is working. The Seabrook ASR Working Group was initially founded to address any current license (10 CFR Part 50) issues. Any future activities, until a possible current license LAR is submitted, will involve inspection and public outreach which are generally activities led by the region.

Tony McMurtray

B1:C

Chief, Mechanical & Civil Engineering Branch (EMCB)
Division of Engineering (DE)
Office of Nuclear Reactor Regulation
(301) 415-2746

Marshall, Michael

From:	Green, Rodneshia
Sent:	Thursday, June 13, 2013 11:50 AM
To:	Khanna, Meena; Ott, William; Kobetz, Timothy; Hogan, Rosemary; McMurtray, Anthony; Schroeder, Daniel; Dentel, Glenn; Cook, William; Raymond, William; Chaudhary, Suresh; Floyd, Niklas; Lamb, John; Plasse, Richard; Sheikh, Abdul; Buford, Angela; Philip, Jacob; Graves, Herman; Fuhrmann, Mark
Cc:	Marshall, Michael; Erickson, Alice
Subject:	Dispatch of Final Document: Position Paper - "Assessment of ACI 318-71 as Design Basis for Category 1 Concrete Structures Affected by ALKALI-SILICA Reaction at Seabrook Station"

View ADAMS P8 Properties ML13128A521
Open ADAMS P8 Document (Memo re: Position Paper -"Assessment of ACI 318-71 as Design Basis for Category I Concrete Structures Affected by Alkali silica Reaction at Seabrook Station.")

Date: June 10, 2013

Memorandum to: James M. Trapp, Chief, Seabrook Alkali-Silica Reaction Issue Technical Team Chairman

Thru: Michael Marshall, BC/RASB/DLR

From: Alice Erickson, Structural Engineer, RASB, DLR

Subject: Position Paper – "Assessment of ACI 318-71 as Design Basis for Category 1 Concrete Structures Affected by
Alkali-Silica Reaction at Seabrook Station"

Rodneshia Y. Green
NRR/DLR Administrative Assistant
(301) 415-1183
U.S. Nuclear Regulatory Commission
RODNESHIA.GREEN@NRC.GOV

B\120

Buford, Angela

From: Buford, Angela
Sent: Friday, June 14, 2013 12:18 PM
To: Trapp, James
Subject: Question: Dates of Seabrook Exit

Good afternoon Jim!

Just wanted to verify Michael Marshall's info: what is the schedule for the Seabrook exit?

Angela R. Buford | Structural Engineer
Division of License Renewal
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852
t: 301.415.3166
angela.buford@nrc.gov

Marshall, Michael

From: Marshall, Michael
Sent: Monday, June 17, 2013 7:24 AM
To: Lubinski, John; Pelton, David
Subject: Expanded ET Input - RASB

Hello John and Dave,

- Next week on June 25th, Region 1 has scheduled a joint briefing with Eric Leeds and Bill Dean to discuss status of the Seabrook ASR issue and to obtain agreement with closing the Seabrook ASR CAL and keeping the Seabrook ASR Issue Working Group active. The closure of the CAL will be a communication challenge, because the Seabrook ASR issue will not be fully resolved for at least a couple more years. The resolution hinges on anchorage and beam tests the licensee is sponsoring at the University of Texas at Austin that is currently scheduled for completion in CY2015. However, the actions that the licensee has planned and the timetable to implement their plan is reasonable.
- Next week on June 26th and 27th, DLR (i.e., Angie Buford) will be providing technical support for the final inspection at Seabrook to close out the Seabrook ASR CAL.

Michael L. Marshall, Jr.
Chief
Aging Management of Structures, Electrical, and Systems Branch
Division of License Renewal
Office of Nuclear Reactor Regulation

301-415-2871
Email: michael.marshall@nrc.gov

B122

Buford, Angela

From: Buford, Angela
Sent: Thursday, June 20, 2013 2:43 PM
To: Cook, William
Subject: RE: Meeting Forward Notification: ASR Chemical Prestress

Thanks Bill! When I originally wanted to schedule it the meeting was going to be on Tuesday so I hadn't included Nik and Jim, but George is not available then, so it will actually work out well that we can all participate

---

From: Microsoft Exchange **On Behalf Of** Cook, William
Sent: Thursday, June 20, 2013 2:42 PM
To: Buford, Angela
Subject: Meeting Forward Notification: ASR Chemical Prestress

Your meeting was forwarded

Cook, William has forwarded your meeting request to additional recipients.

Meeting

ASR Chemical Prestress

Meeting Time

Wednesday, June 26, 2013 9:30 AM-10:30 AM.

Recipients

Trapp, James

Floyd, Niklas

All times listed are in the following time zone: (GMT-05:00) Eastern Time (US & Canada)

Sent by Microsoft Exchange Server 2007

B123

Marshall, Michael

From: Rodriguez, Veronica
Sent: Thursday, June 20, 2013 2:59 PM
To: McMurtray, Anthony; Marshall, Michael
Subject: Preps for ASR mtg on the 25th

Importance: High

Eric won't be able to attend the meeting on the 25th w R1. Michele Evans will be covering the mtg for Eric. However, we will be providing a pre-briefing for Eric on Mon the 24th at 3pm just to bring him up to speed and address any Qs or concerns that he may have. This will ensure that Michele can convey Eric's thoughts at the mtg. **R1 has been informed and they have no objection.**

John L. will be ready to brief Eric but I figure that you may want to participate. Not sure if you want to bring your mgmt. as well. I don't think is necessary but I'll leave this up to you.

I do want to point out that this will be a VERY short meeting. We only have 30 mins in the calendar (15 mins to discuss the CAL w Eric, and 15 mins to discuss another issue w him and Jennifer on a security-related finding for OC). So, we'll go straight to the point. ☺ The meeting will take place on 13D20 at 3pm. I'll FW the scheduler in a sec. Pls share scheduler, if deemed necessary (due to the time constraints, I would recommend that you only invite those that absolutely need to be in attendance).

Lastly, since there will be a few of us participating in the mtg on the 25th, I have reserved 13D20. We can all meet on the 13th floor and call R1 from there. I'll make sure that R1 updates the scheduler w this information.

Please call me to discuss or if you have Qs. I've been trying to reach you but I have been unsuccessful. (Will be here until 430. I'm off tomorrow).

Thanks a bunch,
Veronica

B124

From:	Sheikh, Abdul
To:	Erickson, Alice
Subject:	seabrook
Date:	Monday, June 24, 2013 8:42:21 AM
Attachments:	IR 2012-010 draft -abdul comments.docx

B125

ENCLOSURE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
2100 RENAISSANCE BOULEVARD, SUITE 100
KING OF PRUSSIA, PENNSYLVANIA 19406-2713

Mr. Kevin Walsh
Site Vice President
Seabrook Nuclear Power Plant
NextEra Energy Seabrook, LLC
c/o Mr. Michael O'Keefe
P.O. Box 300
Seabrook, NH 03874

SUBJECT: SEABROOK STATION, UNIT NO. 1 - CONFIRMATORY ACTION LETTER FOLLOW-UP INSPECTION - NRC INSPECTION REPORT 05000443/2012010

Dear Mr. Walsh:

On *June 27*, 2013, the U. S. Nuclear Regulatory Commission (NRC) completed a team inspection at Seabrook Station, Unit No. 1. The enclosed inspection report documents the inspection results, which were discussed on *June 27*, 2013, with you and other members of your staff.

The team inspection examined activities conducted under your license as they relate to safety and compliance with the Commission's rules and regulations and with the conditions of your license. Specifically, the team reviewed selected procedures and records, observed activities, and interviewed station personnel regarding the adequacy of NextEra's actions to address the impact of Alkali-Silica Reaction (ASR) on reinforced concrete structures. The team reviewed selected Confirmatory Action Letter (CAL) 1-2012-002 commitments for adequacy and closure.

Based upon the inspection team (team) on site and in-office reviews, the remaining five CAL items were reviewed and closed, as documented in the enclosed report.

The NRC determined that

It should be noted that the inspection team results are based solely on Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 requirements. The NRC is currently in the process of conducting a separate review of the ASR issue as part of the license renewal process in accordance with 10 CFR Part 54. As such, certain aspects of the ASR issue discussed may also have applicability to the license renewal review and involve additional consideration and require additional information beyond that discussed in this report.

In accordance with 10 CFR 2.390 of the NRCs "Rules of Practice," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of the NRC's document system (ADAMS). ADAMS is accessible from the NRC website at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

Christopher G. Miller, Director
Division of Reactor Safety

Docket No. 50-443
License No: NPF-86

Enclosures:
1. Inspection Report No. 05000443/2012010
   w/ Attachment: Supplemental Information
2. Confirmatory Action Letter 1-2012-002

cc w/encl: Distribution via ListServ

It should be noted that the inspection team results are based solely on Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 requirements. The NRC is currently in the process of conducting a separate review of the ASR issue as part of the license renewal process in accordance with 10 CFR Part 54. As such, certain aspects of the ASR issue discussed may also have applicability to the license renewal review and involve additional consideration and require additional information beyond that discussed in this report.

In accordance with 10 CFR 2.390 of the NRCs "Rules of Practice," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of the NRC's document system (ADAMS). ADAMS is accessible from the NRC website at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

Christopher G. Miller, Director
Division of Reactor Safety

Docket No. 50-443
License No: NPF-86

Enclosures:
1. Inspection Report No. 05000443/2012010
   w/ Attachment: Supplemental Information
2. Confirmatory Action Letter 1-2012-002

cc w/encl: Distribution via ListServ

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C. Santos, RI, OEDO
RidsNrrDorlLpl1-2 Resource
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DOCUMENT NAME: G:\DRS\Seabrook Concrete\Oper-funct - TIAs\CAL FU 92702 Report 1\IR 2012-009 12-03-12.docx
ADAMS Accession No.: ML

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OFFICE *mmt*	RI/DRS	RI/DRP	RI/DRS	RI/DRS
NAME	WCook	GDental	JTrapp/	CMiller/
DATE	/ /13	/ /13	/ /13	

OFFICIAL RECORD COPY

U.S. NUCLEAR REGULATORY COMMISSION

REGION I

Docket No.:	50-443
License No.:	NPF-86
Report No.:	05000443/2012010
Licensee:	NextEra Energy Seabrook, LLC
Facility:	Seabrook Station, Unit No. 1
Location:	Seabrook, New Hampshire 03874
Dates:	November 3, 2012 to April 30, 2013
Inspectors:	W. Cook, Team Leader, Division of Reactor Safety (DRS) S. Chaudhary, Reactor Inspector, DRS W. Raymond, Senior Resident Inspector A. Buford, Structural Engineer, Division of License Renewal (DLR), Office of Nuclear Reactor Regulation (NRR) G. Thomas, Structural Engineer, Division of Engineering, NRR A. Sheikh, Senior Structural Engineer, DLR, NRR
Approved by:	James Trapp, Chief, Engineering Branch 1 Division of Reactor Safety

SUMMARY OF FINDINGS

IR 05000443/2012010; 11/03/2012 - 07/01/2013; Seabrook Station, Unit No. 1; Confirmatory Action Letter (CAL) Follow-up Inspection Report.

This report covered ____ weeks of onsite inspection at Seabrook Station, two weeks of inspection at the University of Texas – Austin, and ____ months of in-office review by region based inspectors and headquarters reviewers to assess the adequacy of actions taken by NextEra to address the occurrence of Alkali-Silica Reaction (ASR) in reinforced concrete structures at Seabrook Station. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process," Revision 4, dated December 2006.

Cornerstone: Mitigating Systems

During this second CAL follow-up inspection, the team examined the remaining six commitments identified in CAL No. 1-2012-002, dated May 16, 2012. The CAL Items reviewed and closed via this inspection were 2, 4, 7, 8, 9 and 11. In addition, a number of observations documented in the first CAL follow-up inspection (reference Inspection Report 05000443/2012009, Section 9.0) were reviewed and closed in this report. Closure of CAL Item 7 was administrative, in that, NextEra had withdrawn this commitment by letter dated December 13, 2012. NextEra's revision to this commitment was approved by the NRC as documented in the CAL revision letter dated January 14, 2013. The details of the team's review of each closed CAL item are documented in the enclosed report.

Although the review and closure of each CAL item signifies the NRC's satisfactory assessment of NextEra's commitments and planned corrective actions to address the non-conforming alkali-silica reaction in Seabrook reinforced concrete structures, the completion of this CAL follow-up inspections and closure of the CAL, itself, is not the completion of NRC review and oversight of NextEra's actions to address this issue. As discussed in the team's review of CAL Item 4 and the revised ICAP submitted on May 1,2013, NextEra acknowledges that a license amendment request, pursuant to 10CFR50.59, may be submitted to address the change in structural evaluation methodology necessitated by the discovery of ASR and the method elected by NextEra to monitor and provide reasonable assurance of continued operability and functionality of ASR-affected reinforced concrete structures.

Comment [A1]: What about design basis?

The team observed that in 18 of 26 monitored locations the increased CCI values were small but greater than measurement uncertainty. Thus, the ASR degradation in the Seabrook structures appears to be active and measurable in some locations. Based upon ASR degradation being a slow process and the Seabrook structures being impacted by ASR in only a small fraction of any structural member, vice uniformly and completely affected, the crack index and expansion measurements show no appreciable structural changes and therefore no eminent challenges to the conclusions in the current prompt operability determinations. However, the team's observations highlight the need for NextEra to continue the 6-month measurements and trending until (i) a stable pattern in the CI measurement data is evident and the results are reliable and predictable (on a building specific basis); and, (ii) tests at the UT-

Comment [A2]: Do you plan to discuss the status of other locations where CCI was less than 1.0 mm/m in the first walkdown.

Austin FSEL are completed and the results appropriately incorporated into a final operability determination.

REPORT DETAILS

1.0 Background

Alkali-Silica Reaction (ASR) is a chemical reaction occurring in hardened concrete that can change the physical properties of the concrete and potentially affect structural performance. In June 2009, NextEra identified potential degradation in below-grade concrete structures at Seabrook. In August 2010, NextEra completed petrographic evaluation of concrete core samples, which confirmed ASR as the degradation mechanism. The degraded condition in numerous Seabrook Category I structures was evaluated in the Corrective Action Program via prompt operability determinations (PODs). The PODs were revised as new information became available and improved analytical techniques were incorporated.

NextEra initially used the results of mechanical testing of concrete cores to assess the degree of structural degradation due to ASR. This is the traditional method described in American Concrete Institute (ACI) 228.1R for assessing existing concrete structures. NextEra tested the cores for compressive strength and elastic modulus. NextEra used the methods defined in construction and design code ACI 318-1971 to evaluate the structural capacity (operability) of the ASR-affected buildings. However, the mathematical relationships in ACI-318 are based on empirical data from testing of non-degraded concrete, and these relationships may not hold true for all stages of ASR-affected concrete.

After further review of industry experience and literature pertaining to ASR, NextEra engineering concluded that the core test data was not indicative of structural performance of ASR-affected reinforced concrete structures. NextEra's engineering evaluation stated that once the cores are removed from the structure, concrete core samples are no longer subject to the strains imposed by the ASR-related expansion or restraints imposed by the steel reinforcing cage. The engineering evaluation also stated that confinement provided by steel reinforcing bars (rebar) and other restraints limit ASR expansion of the concrete within the structure and thereby limit the adverse impact on structural performance. Therefore NextEra engineering concluded that the reduction of mechanical properties observed in mechanical testing of cores was not representative of in-situ concrete performance. Based on this engineering judgment, NextEra stopped taking core samples to evaluate the concrete mechanical properties of structures impacted by ASR and revised the operability assessment approach. NextEra's current approach for assessing structural integrity and operability is to compare available design margins to an assumed reduction in structural capacity due to ASR.

NextEra's operability evaluations were based upon an examination of available design margins and a presumed ASR-caused reduction in structural design capacity for critical limit states. The details of this methodology and related assumptions were developed in NextEra's Interim Assessment (FP 100716). The assessment assumed lower bound values of structural capacity for ASR-affected concrete for limit states based on research test data, primarily from test specimens. The assessment focused on the structural limit states that are the most sensitive to ASR effects (i.e., out-of-plane shear capacity, lap splice development length, and anchorage capacity). The assessment determined the structures were suitable for continued service. A

Comment [A3]: I was not involved in this assessment and cannot comment on this.

final operability assessment will be conducted by NextEra following evaluation of structural performance based on a proposed large scale testing program of beam specimens representative of Seabrook reinforced concrete structures. The test program has been initiated at the Ferguson Structural Engineering Laboratory at the University of Texas at Austin (UT-A), with some testing (anchors) commenced in 2013 and large beam testing completed by 2015. Based upon the slow progression of the ASR, the current operability evaluations, coupled with the Structures Monitoring Program six-month combined crack indexing, provide reasonable assurance of continued structural operability while the testing program is completed over the next couple of years.

2.0 Confirmatory Action Letter 1-2012-002

Confirmatory Action Letter (CAL) 1-2012-002, dated May 16, 2012, was written to confirm commitments by NextEra (established during a meeting with NRC management and staff on April 23, 2012) with regard to planned actions to evaluate ASR-affected reinforced concrete structures at Seabrook Station. In response to the CAL, NextEra committed to provide information to the NRC staff to assess the adequacy of NextEra's corrective actions to address this significant condition adverse to quality. CAL 1-2012-002 is provided as an Enclosure to this report. The NRC staff also formed a working group to provide appropriate oversight of NextEra's activities to address ASR and to coordinate NRC inspection and review activities. The ASR Working Group Charter (ML121250588) outlines the regulatory framework and general acceptance criterion for NRC oversight and review of this issue. As documented in NRC Inspection Report No. 05000443/2012009, dated December 3, 2012 (ML12338A283) CAL Items 1, 3, 5, 6, and 10 were closed.

Based on the results of this inspection, CAL Items 2, 4, 7, 8, 9, and 11 are closed.

3.0 Review of Structures Monitoring Program (CAL Item #9)

Inspection Scope

CAL No. 1-2012-002 documented NextEra's commitment (CAL Item #9) to implement an update to the Maintenance Rule (10CFR50.65) Structures Monitoring Program (SMP) to include monitoring requirements for selected locations in areas that exhibit ASR by July 15, 2012. This commitment was implemented via a revision (Revision 2) to Structural Engineering Standard 36180, "Structural Monitoring Program," dated July 12, 2012. The team reviewed Revision 2 and discussed the changes with the responsible NextEra engineering staff. The principle changes incorporated in Revision 2 to the SMP were: 1) the addition of Federal Highway Administration (FHWA) document FHWA-HIF-09-004, "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction in Transportation Structures," as a reference document; 2) the periodic (every six months) performance of crack indexing on selected locations (26) to collect quantitative information on the progression of ASR expansion/degradation; and, 3) the establishment of active individual crack width and Combined Crack Index (CCI) measurement thresholds for conducting structural evaluations of the affected structures (reference Foreign Print 100716, "Seabrook Station: Impact of ASR on Concrete Structures and Attachments," and the team's previous review of CAL Item 3 in Inspection Report No. 05000443/2012009, Section 3). The team used ACI 349.3R, "Evaluation of Existing Nuclear Safety-Related Concrete

Structures," as a reference to judge the depth and breadth of NextEra's actions to appropriately monitor the progression of ASR in concrete reinforced structures at Seabrook. The team notes that ACI 349-3R is an American Concrete Institute (ACI) committee report, and does not constitute a recognized industry code or standard. Likewise, ACI 349.3R is not formally endorsed by the NRC, nor has NextEra included ACI 349.3R in their current licensing basis (CLB). Rather, ACI 349.3R provides generally accepted industry guidance and a variety of recommendations for evaluating and monitoring the condition of reinforced concrete structures.

Findings and Observations

The team identified no findings in this area, and CAL Item #9 is closed. However, the team made a number of observations associated with their review and closure of this CAL item, as discussed in the following paragraphs.

Based on a detailed review of SMP Revision 2, the team identified that NextEra had implemented a limited number of the evaluation and monitoring methods outlined in ACI 349.3R. The team confirmed that NextEra had incorporated the three-tiered visual inspection criteria, outlined in Sections 5.1 through 5.3 of ACI 349.3R. NextEra had also augmented this visual inspection criteria with periodic (six-month intervals) CCI measurements and associated structural evaluation thresholds based upon CCI results. The CCI monitoring, performed at 26 selected locations (including containment) was selected by NextEra based upon this method being endorsed by the Federal Highway Administration (FHWA) and outlined in FHWA-HIF-09-004, "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction (ASR) in Transportation Structures," dated January 2010. Based upon discussions with the responsible NextEra engineering, MPR and UT-Austin staffs, the results of the UT-Austin testing program will be used to further validate this methodology for the specific application at Seabrook and to develop additional monitoring techniques of structural properties, as appropriate.

The team understands that crack growth and measurement provides a visual indicator of the progression of ASR within a reinforced concrete structure. The relative width and number of visible cracks may be correlated to the overall progression of ASR and its impact on structural performance and to the specific reinforcement design and associated confinement of concrete ASR expansion by the rebar cage. The adequacy of the CCI measurement as a long term structural monitoring methodology is being evaluated by NextEra via the UT-Austin FSEL testing program.

The team concluded that additional methods outlined in ACI 349.3R could be implemented for monitoring ASR progression at Seabrook. Through follow-up discussions with the responsible engineering staff, the team identified the following additional monitoring methods and activities were being implemented or considered by NextEra to improve the SMP:

Evaluation of infiltration water chemistry and groundwater monitoring: ACI 349.3R discusses environmental monitoring and related effects of aggressive water chemistry, including the potential for leaching. The team observed that the SMP should directly integrate or reference the monitoring of water infiltration and ground water chemistry via an established periodic sampling, analysis, and trending program. NextEra agreed with this observation and revised the SMP (reference Revision 3, dated 4/30/2013) to enhance and incorporate environmental monitoring into the program. **[FOLLOW-UP WITH REVIEW OF WATER SAMPLING PROGRAM – CERTREC DOCUMENT REQUEST 5/31/13, AND PRESENTATION LAST WEEK ON SITE]**

Periodic coring and petrographic examinations may serve to better track the progression of ASR and assist in validating the current CCI monitoring program results. The team understands that NextEra plans to conduct additional core sampling for petrographic examination of ASR-affected walls at Seabrook. NextEra plans to use the results to more closely correlate the UT-Austin test specimen results to the Seabrook structures operability determinations.

Tier II structural inspection activities will be added to SMP. The team learned that NextEra is currently conducting 2.5-year interval CCI measurements of all Tier II (CCI values of between 0.5 mm/m to 1.0 mm/m) identified structures. These CCI measurements do not use fixed pins, but rather use permanent marked areas to endure repeatability and comparability for future reference. NextEra revised the SMP (reference Revision 3, dated 4/30/2013) to formally monitor this sub-set of ASR-affected structures to ensure appropriate corrective actions are taken when established CCI thresholds are exceeded.

Based upon developments in the UT-Austin test facility and the expressed need to better monitor through-wall expansion of non-triaxially reinforced members, NextEra installed deep pins in the UT-Austin test specimens for improved expansion monitoring in this third dimension. NextEra is considering the efficacy of installing deep pins in accessible ASR-affected walls at Seabrook to improve the ability to monitor ASR progression and to better correlate test data to site structures.

Upon completion of the test program, NextEra plans to revise the SMP with any adjustments to CCI evaluation or remediation thresholds, as appropriate.

Comment [A4]: The current license will expire in 2030 and renewed license will expire in 2050. Two independent literature studies conducted by University of Berkeley for USNRC and University of Toronto for Canadian Nuclear safety Commission recommend performing detailed finite element analysis to predict future performance. In addition during the visit to UT, professor Bayrak also stated they have hired a faculty member from University of Tornoto to conduct such studies. Office of Research proposed program also include such a study. For this purpose, there is need to install pins in structure to monitor long term global displacement of structures, specially containment and containment enclosure buildings. The applicant should be asked to plan for such a study that can be completed say by 2018.

Upon completion of the Phase 3 walkdowns, NextEra plans to revise the SMP with any gained insights.

In summary, the team observed that the implemented or planned SMP enhancements may provide NextEra with a more comprehensive understanding of the current extent of ASR progression in affected structures and more thorough monitoring capability of the environment contributing to ASR. From a performance-based perspective, NextEra's initial set of actions to effectively monitor ASR-affected structures via Revision 2 to the SMP were adequate, but based upon Revision 3 changes, the SMP is more comprehensive and more accurately inclusive of the numerous activities associated with the monitoring and assessment of ASR impact on reinforced structures on site.

4.0 Review of Anchor Testing (CAL Item 11)

Background

The micro-cracking caused by ASR can negatively impact the structural capacity of anchors that support safety-related piping, cable trays and other components. NextEra's initial operability determinations were supported by anchor performance testing conducted on readily available ASR degraded specimens previous fabricated or obtained at the UT-Austin test facility (reference FP 100718). As documented in inspection report No. 05000443/2012010, the initial testing demonstrated satisfactory performance of the anchors in ASR-affected concrete during the earlier stages of ASR progression. NextEra's evaluation also illustrated that the eventual reduction in capacity due to ASR was sufficiently offset by established anchor manufacturer's design margins (FP 100716) in the specimens tested. However, based upon the limitations of the testing performed (on ASR-affected test specimens of different composition and compressive strength than Seabrook reinforced concrete structures) NextEra planned to conduct further testing. The planned testing involves anchors installed (both during specimen fabrication and post-fabrication) in ASR-affected test specimens that more closely replicate the reinforced concrete structures and anchor configurations at Seabrook.

Comment [A5]: For operability evaluations or for design basis loads?

Inspection Scope

By licensee letter dated December 13, 2012, (ML12362A323) NextEra requested a revision to CAL Item 11 to address a schedule challenge to the targeted anchor testing program completion date. NextEra also proposed redefining CAL Item 11 to be consistent with the wording of CAL Item 8 regarding large-scale specimen testing. Specifically, NextEra revised their commitment to read, "Submit technical details of the anchor test program planned at the contracted research and development facility by February 28, 2013." The original commitment read, "Complete anchor test program by December 31, 2012. Results will be available for NRC review approximately 30 days after testing is complete." Based upon unforeseeable specimen fabrication schedule delays and the slow progression of accelerated ASR aging, NextEra identified that it would not be possible to complete the anchor testing per the original commitment date. The NRC accepted NextEra's revised commitment by NRC letter dated January 14, 2013 (ML13014A555).

The team reviewed the details and adequacy of NextEra's anchor testing program as outlined in the proprietary "Anchor Testing Program Overview," dated February 26, 2013. This testing program overview and associated testing specifications were docketed for NRC review via NextEra letter dated March 15, 2013 (ML________). The technical overview document and accompanying specifications outlines the major elements of the proposed anchor testing program, including the key attributes of the fabrication of the test specimens, monitoring of the specimens as accelerated ASR aging progresses, and the details of the testing of individual anchor bolt configurations via both pull-through, pullout, and concrete breakout testing methods.

Comment [A6]: I did not review this document

Findings and Observations

The team identified no findings. Based upon the team's review, CAL Item 11 is closed.

During the team's visits to the UT-Austin FSEL facility, the team observed the conditions and controls implemented for the aging of the test blocks and testing of concrete sample cylinders for compressive strength and Modulus of Elasticity. The team witnessed appropriate implementation of the testing procedures by the FSEL students and faculty and proper oversight of these activities by the MPR responsible engineering and quality assurance staff.

At the conclusion of the inspection, NextEra had not achieved the desired ASR progression of the test blocks to conduct the first round of ASR-affected anchor testing. The team did review the results of the control specimen anchor testing and identified --------- issues of concern. [TEAM REQUEST AND REVIEW DOCUMENTATION OF CONTROL SPECIMEN ANCHOR TEST RESULTS – 5/31/13.]

Comment [A7]: Not reviewed

5.0 Prism Testing Commitment Withdrawn (CAL Item 7)

This CAL Item involved NextEra's commitment to "Complete long term aggregate expansion testing (ASTM C 1293, Concrete Prism Test) by June 30, 2013." The purpose of this CAL item was to determine, in conjunction with the Mortar Bar Testing (CAL Item 6), if the coarse aggregate contributing to ASR in Seabrook reinforced concrete still contains sufficient reactive silica for the alkali-silica reaction to continue long-term under the existing environmental conditions. Alternatively, these tests could demonstrate that the progression of ASR at Seabrook maybe self-limiting due to the depletion of reactive silica in the concrete. The Prism Test (as defined by ASTM C1293) involves monitoring the expansion (by measurement of specimen elongation due to ASR) of the test specimen (a molded concrete brick approximately 3 by 5 by 12 inches in length) for a one-year duration. Expansion in excess of 0.04% is considered potentially deleterious and a positive test for slow reactive aggregate. The Prism Test is similar to the Mortar Bar Test (reference ASTM C1260) which has a 14-day duration and an expansion limit of 0.1%.

Based upon the results of the completed Mortar Bar Expansion Testing (reference NRC Inspection Report No. 05000443/2012009, Section 5.0), NextEra concluded that the available quantities of silica in the concrete would not be depleted in the near term and that additional confirmatory testing via the Prism Test method was not warranted. NextEra ran the Mortar Bar Test several weeks beyond the 14-day test (terminated after 103 days) and observed that the alkali-silica reaction was still progressing at the conclusion of the test, indicating the presence of sufficiently reactive aggregate to maintain ASR for a considerably longer period of time. The team notes that the Mortar Bar Testing involved the reuse of aggregates from Seabrook test cores (concrete that had already experienced appreciable ASR) and similar aggregate from concrete not affected by ASR, to date. The side-by-side comparison of Mortar Bar Testing showed no appreciable difference in ASR or the observed testing induced expansion rates. Accordingly, NextEra concluded the Prism Test would add no significant knowledge to the condition assessment of Seabrook concrete and all Seabrook reinforced structures would be determined to be affected by ASR, unless specifically ruled-out by further analysis, such as petrographic examination. By letter dated December 13, 2012, NextEra requested that CAL Item No. 7 be deleted. By NRC letter dated January 14, 2013 (ML13014A555), the NRC acknowledged and accepted NextEra's technical basis for deleting CAL Item No. 7 and the CAL was revised, accordingly.

Comment [A8]: Did they have any preliminary results for the few months duration they conducted the test?

6.0 Concrete Confinement and Rebar Pre-Stressing

As previously discussed in the NRC Inspection Report No. 05000443/2012009, the team noted that the confinement provided by the steel reinforcement bar (rebar) cage restrains ASR expansion resulting in ASR-induced or "chemical" pre-stressing of affected structural members. The team observed that NextEra had only provided a cursory qualitative explanation of this condition in the Interim Assessment (FP 100716) and the containment structural evaluation (AR

1804477). The team concluded in IR No. 05000443/2012009 that a quantitative evaluation of this condition ~~may be~~ is warranted to address this aspect of the non-conforming ASR condition.

During this inspection, the team reviewed NextEra's detailed explanation of the impact of ASR-induced pre-stressing on reinforced concrete structures **(reference Dr. Bayrak's White Paper)**. In simple terms, the effect of this "chemical" pre-stressing is to both increase the compressive stresses in the concrete (within the rebar cage) and to increase the tensile stresses in the rebar, as long as the rebar cage restraint is sustained. Similar to fabricated pre-stressed concrete structural members, the ultimate load carrying capacity of the reinforced member is not significantly changed by the ASR-induced pre-stress, but the load sharing between the concrete and steel reinforcement bars are altered, resulting in a stiffer structure that more closely replicates a member fabricated with higher compressive strength concrete and steel reinforcements that function closer to established yield limits. The team concluded that the ASR-induced pre-stressing may result in some minor beneficial effects in terms of structural stiffness, but agreed with NextEra's engineering evaluation that this additional structural stiffness, cannot and should not be credited for design purposed. Further, advanced ASR conditions may result in the steel reinforcement strain limits being exceeded that could compromise the overall structural performance. These more advanced ASR conditions would be accompanied by obvious visible indications of severe concrete surface cracking and anchorage slip.

Comment [A9]: It may be better to delete this sentence.

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[PROFESSOR BAYRAK TO PROVIDE A "WHITE PAPER" ON THIS TOPIC FOR TEAM REVIEW per 5/20-21 discussions.]

7.0 Review of Alkali-Silica Reaction Root Cause Evaluation (CAL Item 2)

Inspection Scope

As documented in Inspection Report No. 05000443/2012009, the team reviewed NextEra's response to CAL Item #2, "Submit the root cause for the organizational causes associated with the occurrence of ASR at Seabrook Station and related corrective actions by May 25, 2012," The licensee submitted their root cause evaluation (RCE) via letter dated May 24, 2012. Based upon the team's initial review, the inspectors concluded that the second root cause was not sufficiently characterized in NextEra's May 24, 2012, submittal. Specifically, NextEra did not clearly describe the personnel and organizational factors that led to inadequacies in the Structures Monitoring Program (SMP). The team discussed this observation with the responsible Seabrook staff and NextEra agreed to revise the RCE to more appropriately develop and characterize this second root cause and the associated corrective actions.

NextEra submitted a revised RCE summary for NRC review via letter dated May 1, 2013, (ML ________), Enclosure 1. The team reviewed the revised RCE summary for clarity and appropriateness of associated corrective actions, consistent with guidance outlined in 10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Action," and NextEra's Corrective Action Program (CAP).

Findings and Observations

The team identified no findings. Based upon the team's review, CAL Item 2 is closed.

As documented in Enclosure 1 to the May 1, 2013 letter, NextEra summarized the two root causes, as follows: RC1 – the ASR developed because the concrete mix design unknowingly utilized a coarse aggregate that would, in the long term, contribute to ASR. Although the testing was conducted in accordance with ASTM standards, those testing standards were subsequently identified as limited in their ability to predict slow reactive aggregate that produced ASR in the long term; and RC2 – based on the long standing organizational belief that ASR was not a credible failure mode due to the concrete mix design, dispositions for Condition Reports involving groundwater intrusion or concrete degradation, along with the structures health monitoring program did not consider the possibility of ASR development. In addition, NextEra identified a contributing cause involving the failure of the organization to prioritize groundwater elimination or mitigation resulting in more concrete area exposed to moisture.

The team agreed with NextEra's root cause evaluation. The ASTM concrete aggregate testing standards in effect at the time of construction were properly implemented, but later determined to be ineffective in identifying slow reacting, ASR susceptible aggregates. Those standards were revised by the industry and adopted by NextEra to prevent recurrence. NextEra's determination that the Structures Monitoring Program did not remain current with concrete industry operating experience and associated failure modes, such as ASR, and implementation of a broad periodic review process to ensure all station monitoring programs remain current and effective was determined appropriate by the team. Planned activities to address groundwater infiltration and mitigation actions appear appropriate and will be monitored for effectiveness by the NRC, consistent with our baseline inspection program.

Comment [A10]: I am not aware of any mitigation activities.

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8.0 ASR-Affected Structures Walkdown - Extent of Condition Scope and Assessment

During the previous inspection, the team reviewed the overall thoroughness of NextEra's completed and planned ASR walkdown activities conducted in accordance with FP 100642, "ASR Walkdown Scope," Revision 1, and documented in FP 100705, "Seabrook Station: Summary of Alkali Silica Reaction Walkdown Results," Revision 0. At the time of the inspection, not all of the potentially affected structures had been examined and NextEra had drafted a tentative schedule for the completion of the Phase 3 walkdowns. During this inspection, the team challenged NextEra's final Phase 3 schedule for completeness and to ensure a timely examination of the extent of condition of ASR-affected structures.

As previously documented, NextEra's walkdown was being conducted in three phases. Phase 1 involved examination of readily accessible areas of interest; Phase 2 included examination of coated surfaces identified during Phase 1 inspections (coatings had to be removed to expose the concrete surfaces); and Phase 3 examines normally inaccessible structures and areas (e.g. high radiation, manholes, etc.) which have or will be inspected as the opportunity presents itself (e.g. routine maintenance or outage activities). Team examination of the Phase 3 walkdown areas identified (in addition to the previously documented containment IWL inspection oversight) that the spent fuel pool (SFP) reinforced concrete walls were omitted from the planned Phase 3 walkdown. The SFP walls pose a particular challenge to NextEra due to the limited accessibility of the concrete surfaces. At the conclusion of this inspection, NextEra was working to complete their evaluation of various methods to assess the SFP concrete walls. A target date of June 30, 2013 was established to firm-up the necessary steps to accomplish this task (reference ASR Project Corrective Action Plan, revised April 2013). The team also assessed the timing of the walkdowns for the balance of the areas included in the Phase 3 schedule and concluded the target dates for completion of these walkdowns were reasonable and timely. As evidenced by the observed slow progression of ASR and impacted areas evaluated, to date, no immediate safety concerns arise from ASR-affected reinforced concrete structures. With respect to completing a comprehensive examination of the containment structure, the team agrees with NextEra's determination to complete that inspection concurrent with the scheduled IWL examination scheduled for 2015. The balance of the Phase 3 structures walkdowns are scheduled for completion in mid-to-late 2013 and the April 2014 refueling outage. In summary, the team concluded that NextEra's completed and planned extent of condition reviews for identification of ASR-affected reinforced concrete structures is appropriate.

Comment [A11]: Do you want to add a because statement for this determination.

9.0 Review of Structural Evaluations

As documented in Inspection Report 05000443/2012009, NextEra identified 26 locations (including containment) as having patterned cracking with a combined crack index (CCI) of greater than 1.0 mm/m. Per the Structures Monitoring Program, structures with a CCI of >1.0 mm/m requires a structural evaluation. NextEra's Interim Assessment documented an engineering judgment that biased the performance of detailed structural evaluations to the 11 locations with a CCI > 1.5 mm/m. The locations with a CCI of between 1.0 and 1.5 mm/m (13 locations) were considered bounded by the 11 areas subjected to a detailed evaluation. The lack of a documented structural evaluation for the 13 locations with a CCI of between 1.0 and 1.5 mm/m was a minor performance deficiency which NextEra entered into the Corrective Action Program (AR 1804477 and AR 1819080). During this inspection, the team reviewed Calculation C-S-10168, Revision 2, and FP 100716, "Seabrook Station: Impact of Alkali-Silica Reaction on Concrete Structures and Attachments," Revision 2, which provided additional evaluations for the 13 locations. In report "Impact of ASR on Structures (FP100716. Revision 2), NextEra documented the results of the evaluation of 13 structural areas with crack index greater than 1.0, not previously evaluated in the Interim Assessment.

The evaluation methodology included reviewing the calculation that governs the design of the structures to determine the design parameters associated with the general area of ASR degradation. The structural element demand and capacity were then noted and the margin calculated for comparison against the potential reductions in capacities caused by ASR. The assumed reductions in capacity were determined based on lower bound values established in industry literature. A summary of the evaluation was provided in Table 3 of FP100716, Revision 2. For areas in which design margins were insufficient to offset reductions, further review was performed to recapture margin. Specifically, for two areas (Electric Tunnel and Discharge Structure), the design calculation used conservative load factors which were lowered to establish more representative demand loads, as described in Calculation C-S-1-10168, Revision 1. NextEra demonstrated additional margin to assure structural integrity despite the assumed reduction in capacity due to ASR. However, in the calculation for Electric Tunnel area MF101 (C-S-1-10168, pg 30), NextEra reduced the hydrostatic load factor (1.4) to achieve a more realistic load demand. NextEra plans to credit the 1.4 load factor in the load demand calculation to establish full qualification per the FSAR licensing basis in the final operability determination, following completion of the testing program at UT-Austin.

Comment [A12]: Other team members reviewed this information. I did not.

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Comment [A13]: Perhaps you may want to identify the conservative load factor magnitude.

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Comment [A14]: For operability evaluation?

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The team determined that NextEra's initial approach to perform a bounding analysis only for areas with CI >1.5 mm/m was not conservative, because the design margins vary in each structural member of each reinforced concrete structure. These observations highlight the need, once the impact of the ASR degradation on structural capacities is determined from the UT-Austin FSEL test program, for NextEra to closely review the design calculations for each ASR impacted area to assure margins remain acceptable without having to remove or reduce the load factors assumed in the current licensing basis.

10.0 Review of ASR Expansion Measurements

Inspection Scope

The team reviewed the periodic concrete expansion measurements for ASR-impacted Seabrook structures. Specifically, the team examined the supporting documentation for the ASR Crack Index Report dated 3/18/13 (FP 100811) and the ASR Expansion Measurements Report dated 3/18/13 (FP100812). The team also conducted interviews and discussions with the responsible NextEra engineering staff. The team used 10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Action," and Criterion XI, "Test Control," as the regulatory guidance to assess the adequacy of NextEra's actions to address ASR-affected reinforced concrete structures.

Findings and Observations

No findings were identified. Overall, the combined crack index (CCI) data show some evidence of continued ASR degradation, but the expansion data (pin to pin measurements) showed no significant changes. There was no change in the CCI data for the containment, but the Electric Tunnel and the Primary Auxiliary Building/Residual Heat Removal (PAB/RHR) vault both show a positive trend in CCI value in the six months since June 2012. Thus, ASR degradation appears to be ongoing in some Seabrook structures as indicated by some minor incremental crack growth. Collectively, the CCI measurements indicate essentially no structural changes; and therefore no challenges to the conclusions in the current ASR-affected structures' prompt operability determinations. The team endorses NextEra's plans to continue the 6-month CCI measurements to establish a stable trend in observable ASR expansion for each uniquely ASR-affected structure. Continued periodic measurements should eventually eliminate the potential influence of seasonal ambient temperature changes from the trend results.

CCI Measurements

In the ASR Crack Index Report (FP100811), NextEra measured CCI values for 26 locations in the monitoring program and compared the results to the data taken in June 2012. The CCI data shows an apparent increase in most (18 of 26) of the monitored locations. NextEra identified that the CCIs measured in December 2012 appears larger than the CCI data measured in June 2012. NextEra concluded the apparent increase in CCI values was due to seasonal temperature variations because the concrete (in December) was significantly colder, which may cause the concrete to contract between the cracks, increasing the apparent crack widths.

The team noted that 3 of 7 monitored locations on the exterior of plant buildings (above grade and more susceptible to seasonal temperature and moisture variations), showed a decrease in CCI from June to December. Further, 15 of 18 areas showing an increase in crack index were areas monitored on interior buildings surfaces and/or below grade; and therefore less susceptible to seasonal temperature variations. In particular, the Electric Tunnel (areas 3b, 4, and 5) and the PAB/RHR Vault (areas 17, 18, 22, and 23) all show a CCI value increase of between 0.20 to 0.26 mm/m compared to June 2012. These interior, below-grade areas have been chronically wet from ground water infiltration. The team noted there was no change in the CCI values for the Containment Building (Location 14 - Mechanical Penetration MF102-01).

As reported by NextEra, uneven cracking (total crack width in one direction is much larger than in the other direction) and measured larger cracks were identified in the horizontal direction compared to the vertical. The team observed that, over the long term, averaging the horizontal and vertical CCI values may be an adequate representation of overall changes due to ASR of the specific structural member. However, the practice of averaging the horizontal and vertical CCI values is different than outlined by available industry guidance (FHWA-HIF-09-004) that recognizes the influence of reinforcements on crack growth. Thus, reporting an averaged CCI vice directional CCI values separately, could mask the expansion in a preferred direction and hamper the identification of a trend, in the short term. NextEra acknowledged this team observation and initiated a Condition Report (CR) to evaluate this issue (need CR #).

The team also noted that NextEra revised the method of calculating CCI in the recent 6-month measurement report (December 2012). The CCI measurement reporting method was changed to account for the use of rectangular grids to determine crack index, and thereby normalize index to the total number of lines in the both directions. In so doing, NextEra recalculated the CCI values for the December 2011 and June 2012 data to eliminate potential biasing errors. The team concluded that NextEra's more consistent use of a calculation method would aid the identification of apparent trends.

Structure Expansion Measurements

In the Expansion Measurement Report (FP100812), NextEra performed measurements between pins embedded in the surface of plant buildings at the 26 established CCI monitoring locations. The 26 monitored locations were selected from the 131 locations identified in the ASR Walkdown Report (reference FP100705) which exhibited the highest visible ASR-associated distress. NextEra noted a null result for expansion measurements between pins in most of the 26 monitored locations. Specifically, data recorded in most (436) measurement lines showed no significant changes compared to the baseline data. However, for 5 of the 436 measurement lines, NextEra noted length changes that were unexpected. Further, NextEra noted that the gage points at CCI monitoring locations 1, 9, and 14 had moved out of range of the measurement instrument. NextEra plans to evaluate these locations further.

The team noted that the crack index data shows apparent increase when expansion data in 2-dimensions shows no change. It appears that the CI data better reflects expansion (strain) in the structure compared to the expansion measurements in only 2-dimensions, which may not be a complete indicator of changes in the structure. The team noted that NextEra plans to add deep pins to ASR impacted walls in the monitored locations that will allow expansion measurements in the third direction.

11.0 Aircraft Impact Review

Comment [A15]: Please see if this section needs to be revised. This can lead to discussion about the new aircraft impact assessment rule.

The team reviewed the NextEra's recent evaluation of the aircraft impact study performed in response to the identification of ASR. The aircraft impact study for Seabrook containment is described in UFSAR Section 3.8.1.3 and Appendix 2P. As noted in the UFSAR, the postulated aircraft impact load is not combined with any other containment transient design loading. Further, the study assumes the impact area to be on the dome just above the spring line. The effects of an aircraft impact were found not to be controlling for overall design considerations. Also, the analysis assumes that the enclosure building fails when struck by the aircraft and deforms until the aircraft contacts the containment structure. The containment enclosure building design and analysis is described in UFSAR Section 3.8.4. NextEra's evaluation states that ASR has only been identified below grade in the containment and containment enclosure buildings, where sufficient moisture has supported ASR progression. Above grade and in the vicinity of the anticipated aircraft impact area, there is no detrimental ASR affect. Accordingly, NextEra concluded that the Seabrook aircraft impact study remains valid and unaffected by the identification of ASR-affected reinforced concrete structures.

12.0 Integrated Corrective Action Plan (CAL Item #4)

Inspection Scope

CAL No. 1-2012-002 documented NextEra's commitment to submit the corrective action plan (CAL Item 4) for the continued assessment of ASR in concrete structures at Seabrook Station including development of remedial actions to mitigate the affects of ASR, where warranted, by June 8, 2012. By letter dated June 8, 2012 (ML12171A227) NextEra submitted their integrated corrective action plan (CAP) for NRC review. The CAP outlined the major elements of diagnosis, evaluation, prognosis and mitigation of ASR-affected structures as understood at the time. Since June 8, NextEra made considerable progress in refining the elements of this plan, implementing the initial phases, and more clearly focusing future actions. Consequently, by letter dated May 1, 2013 (ML________) NextEra provided an updated ASR Project CAP (reference Enclosure 2).

The team reviewed the integrated CAP and discussed details of each element with the responsible NextEra staff. As documented in Inspection Report No. 05000443/2012009 and in other sections of this report, the team evaluated completed and ongoing ASR-related activities identified in the CAP.

Findings and Observations

The team identified no findings. Based upon the team's review, CAL Item 4 is closed.

Over the past six months of this inspection period, the team has had numerous discussions, meetings and onsite inspections at both Seabrook Station and at UT-Austin to review NextEra's actions to address the ASR-affected reinforced concrete structures. From these interactions, both the team and NextEra has gained greater clarity and understanding of the necessary steps to address this non-conforming condition impacting safety-related structures. Some of the highlights of these interactions are reflected in the revised ASR Project CAP and discussed below:

- Combined Crack Indexing (CCI) will likely become the principle method used by NextEra for monitoring the progression of ASR in affected structures. However, this method is not recognized by NRC regulatory and design standards or within the current licensing basis. Pending the results of the UT-Austin FSEL testing program, NextEra may seek a license amendment to credit this methodology for use in completing the operability determinations associated with ASR-affected structures. CCI may be applied as a surrogate to more traditional methods of verifying structural design capacities.
- In support of the use of CCI, which is a two-dimensional concrete surface measurement, NextEra is developing plans to install deep pins in ASR-affected walls at Seabrook to better monitor ASR progression. The large scale test specimens fabricated at the UT-Austin facility include three-dimensional through-wall pin placements which will provide a more comprehensive measurement of the ASR expansion and associated impact on structural performance. NextEra hopes to install similar deep pins at the site in order to better correlate the UT-Austin testing results and the two-dimensional CCI data to actual structural performance.
- As discussed in Section 8.0, NextEra is developing plans to examine the SFP walls for potential ASR impact. At the conclusion of this inspection, those plans had not been finalized, but are being tracked per the integrated CAP.
- As discussed in Section 3.0, the Structures Monitoring Program (SMP) was revised to include a number of additional monitoring activities currently being conducted by NextEra. Based upon the results of the testing program and related initiatives, NextEra has a place-keeper in the integrated CAP to revise the SMP to formally track these new or improved structures monitoring techniques.
- Under Section 4.0 of the ASR Project CAP, NextEra acknowledged the likelihood of a license amendment request, pursuant to 10CFR50.59, to credit the test results for demonstrating current and longer term operability and structural performance with ASR-affected concrete. The team observed that this approach appears reasonable and consistent with existing regulatory processes, but did not pre-judge the viability of the outcome.
- As part of NextEra's extent of condition review, evidence of ASR was identified on the exterior surface of containment structure. NextEra initiated a prompt operability determination (No. 1804477) and concluded containment was fully operable and capable of meeting all its design basis functions, with some reduced margin. At the conclusion of this inspection, NextEra had not yet developed a plan for resolving this non-conforming condition. As this issue has been documented in the Seabrook CAP with an open operability determination, resolution of the issue will be monitored via the ROP baseline inspection activities.

13.0 Review of Technical Details of Large Specimen Testing Program (CAL Item #8)

Background

CAL Item 8 committed NextEra to submit the technical details of the testing planned at the contracted research and development facility by June 30, 2012. By letter dated June 21, 2012, (ML12179A281) NextEra submitted the Shear and Lap Splice Testing overview prepared by the Ferguson Structural Engineering Laboratory (FSEL) at the University of Texas at Austin, dated March 15, 2012. The purpose of the test program as described in the FSEL document is to provide sufficient data and insights to establish the current and future implications of ASR on Seabrook reinforced concrete structures. Based upon limited available literature or test data relative to the impact of ASR on walls without transverse reinforcements (like the majority of Seabrook ASR-affected structures) destructive testing of ASR-affected test specimens will be conducted to evaluate the impact of ASR on out-of-plane shear strength and lap splice development. The test specimens being prepared at FSEL will be of representative scale and design, such that the test results may be correlated to Seabrook structures.

The team reviewed the June 21, 2012 submittal and conducted a conference call on December 18, 2012, with the NextEra and UT-Austin FSEL staff to better understand the proposed test program. Based upon the complexity of the information discussed and follow-up inspection activities, NextEra prepared a test program overview document and a detailed test specification to supplement the June 21, 2012 CAL response letter. By letter dated May 1, 2013, (ML______) NextEra provided the NRC with the Seabrook Station - Specification for Shear and Reinforcement Anchorage Testing of ASR-Affected Reinforced Concrete (Enclosures 3 & 4) and Approach for Shear and Reinforcement Testing of Concrete Affected by Alkali Silica Reaction (Enclosure 5 & 6). Each of these documents has a proprietary and non-proprietary version.

Inspection Scope

The team reviewed the revised testing specification and the associated overview document to better understand the overall test program approach and application of test results to resolve the Seabrook ASR-affected concrete non-conforming condition. The team discussed the test program with the FSEL, MPR and responsible NextEra engineering staffs.

Comment [A16]: Do you want to include summary of discussion and agreement to revise the document based on discussion.

Findings and Observations

No findings were identified. Based upon team review of the submitted testing program documents and associated inspection activities to gain a better understanding of NextEra's proposed approach to resolving the ASR issue, CAL Item 8 is closed.

The team observed and NextEra acknowledges that the CAL Item 8 response documents may be referenced in a future license amendment request, but have only been submitted to satisfy NextEra's commitment to outline and explain the scope and depth of the UT-Austin FSEL testing program.

14.0 UT-Austin Ferguson Structural Engineering Laboratory Visits

Scope of Review

On two separate occasions, members of the team visited the UT-Austin testing facility to observe ongoing activities and inspect general facility quality assurance and control measures as implement per NextEra's regulatory obligations. The team understands that NextEra has contractual agreements with MPR Associates and the UT-Austin Ferguson Structural Engineering Laboratory to oversee and conduct, respectively, the ASR large scale testing program. The team toured the facility, including: main fabrication and testing areas with overhead crane lifting capabilities; outside exposed and protected (green house) specimen curing areas, with continuous or cyclic wetting and drying capability; aggregate and sand storage yard; and office and laboratory spaces for storage and use of calibration and test equipment, as well as, environmentally controlled storage units for a variety of mortar bar, prism, and concrete cylinder test specimens. The team examined the large block anchor bolt test specimens, including the control specimen block which had been tested. The team also witnessed fabrication of the second large shear and lap-splice test beam, and some testing of cylinders for compressive strength and Modulus of Elasticity determination.

Findings and Observations

No findings were identified. The team observed overall excellent oversight and quality control practices being implemented. Direct oversight by both UT-Austin supervisory staff and MPR engineers was evident and effective.

Review of Follow-Up Issues

Review of core sample material property testing and SMP (Section 3.2.2);
~~Review quantification of pre-stressing effects of ASR expansion (Section 3.2.8);~~
Assess the need for any further rebar examinations or testing (Section 3.2.9);
~~Review revised RCE submittal (Section 4.2);~~
~~Confirm revised commitment to CAL Item #7 (Section 5.2);~~
Review Crack Indexing and its physical significance for SMP application (Section 6.2); and,
~~Review adequacy of revisions to the Phase 3 walkdown plans and schedule (Section 7.2).~~

14.0 Meetings, Including Exit

On ___________, 2013, the team conducted an exit meeting to discuss the preliminary findings and observations with Mr. Kevin Walsh, Site Vice President, and other members of Seabrook Station staff. The inspectors verified that no proprietary information was retained by the inspectors or documented in this report.

SUPPLEMENTAL INFORMATION

KEY POINTS OF CONTACT

Licensee Personnel
B. Brown, Design Engineering Manager
A. Chesno, Performance Improvement Manager
K. Chew, License Renewal Engineer
R. Cliché, License Renewal Project Manager
M. Collins, Design Engineering Manager
J. Connolly, Site Engineering Director
R. Noble, Project Manager
M. O'Keefe, Licensing Manager
T. Vassallo, Principal Design Engineer
K. Walsh, Site Vice President
P. Willoughby, Licensing Engineer

LIST OF ITEMS OPENED, CLOSED, DISCUSSED, AND UPDATED

Updated
None

Opened
None

Closed

LIST OF DOCUMENTS REVIEWED

Procedures
Maintenance Rule Scoping Document, Revision 0
EDS 36180, Structures Monitoring Program, Revision 0, 1, 2

Corrective Action Documents (AR)
1651969, 1629504, 574120, 581434, 1636419, 1673102, 1647722, 1664399, 1677340, 1687932, 1692374, 1698739, 1755727, 1757861, 1819080, 1804477, 1819069

Drawings

Licensing and Design Basis Documents and Calculations
Seabrook Station UFSAR, Revision 14
ACI 318-71
Calculation CD-20
Calculation CD-18
Calculation C-S-1-10168

Miscellaneous Documents
FP 100348, Statistical Analysis-Concrete Compression Test Data (PTL)
FP 100642, Scope for Alkali-Silica Reaction Walkdowns
FP 100641, Procedure for ASR Walkdowns and Assessment Checklist
FP 100661, Compression Testing Concrete Cores (WJE)
FP 100696, Material Properties of ASR-Affected Concrete
FP 100700, Field Investigation
FP 100705, Structure ASR Walkdown Report (MPR 0326-0058-58)
FP 100714, Three Dimensional Dynamic Analysis of Containment Enclosure Building
FP 100715, ASR Impact Study on Containment Enclosure Building
FP 100716, Interim Assessment: Impact of ASR on Structures (MPR-3727)
FP 100717, ACI 318-71 Perspectives
FP 100718, Anchor Test Report (MPR-3722)
FP 100720, Crack Index and Expansion Measurement
FP 100738, Measurements for ASR Crack Indexing on Concrete Structures
FP 100697, MPR 0326-0058-53, White Paper on Structural Implications of ASR: State of the Art, Revision 1
MPR 0326-0058-83, Shear Screening Criteria Used in MPR-3727
FHWA-HIF-09-004, Federal Highway Administration, "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction in Transportation Structures."

Documents Reviewed at FSEL

1. Purchase Order No. 0326 – 0058 -25, dated December 1, 2011 and change order Nos. 1, dated March 21, 2012; No. 2, dated March 27, 2012; No. 3, dated July 23, 2012; and No. 4, August 2, 2012 between MPR Associates Inc. and Ferguson Structural Engineering Laboratory as applied to Anchor Testing Program

2. Contract No. 02293285, dated June 6, 2011, and Amendment Nos. 1, dated October 25, 2011; No. 2, dated December 17, 2011; No. 003, dated January 3, 2012; No. 004, dated February 27, 2012; Amendment 6, dated July 26, 2012, between NextEra and MPR Associates Inc.

3. MPR Letter to Ferguson Structural Engineering Laboratory, dated December 1, 2011, Notice of Intent to Contract for Testing of Anchors in ASR-affected Concreter – authorizing FSEL to develop project-specific quality system manual, implementing procedures for testing and perform initial characterization of the ASR degradation on girders.

4. MPR Letter to Ferguson Structural Engineering Laboratory, dated December 1, 2011, Research on Performance of Anchors in ASR-affected Concrete

5. MPR Letter to Ferguson Structural Engineering Laboratory, dated March 27, 2012, Research on Performance of Anchors in ASR-affected Concrete

6. MPR Letter to Ferguson Structural Engineering Laboratory, dated July 23, 2012, Research on Performance of Anchors in ASR-affected Concrete

7. MPR Letter to Ferguson Structural Engineering Laboratory, dated August 2, 2012, Research on Performance of Anchors in ASR-affected Concrete

8. MPR Letter to Ferguson Structural Engineering Laboratory, dated October 26, 2012, Research on Performance of Anchors in ASR-affected Concrete

9. Purchase Order No. 0326 – 0063 -01, dated June 4, 2012, between MPR Associates Inc. and Ferguson Structural Engineering Laboratory as applied to Beam Testing Program

10. Contract No. 02207204, dated April 27, 2012, NextEra and MPR Associates Inc., related to ASR Concrete Beam Testing Program (for Shear and Lap-splice anchorage)

11. Project Plan 0326 – 0062 -01, Revision 0, dated May 1, 2012, by MPR Associates Inc. as applied to Beam Testing Program

LIST OF ACRONYMS

ACI	American Concrete Institute
ADAMS	Agencywide Documents Access and Management System
AMP	Aging Management Program
AR	Action Request
ASME	American Society of Mechanical Engineers
ASR	Alkali-Silica Reaction
BRE	Building Research Establishment
CAL	Confirmatory Action Letter
CCI	Combined Crack Index
CEB	Containment Enclosure Building
CFR	Code of Federal Regulations
CW	Circulating Water
DCR	Demand to Capacity Ratios
DGB	Diesel Generator Building
DRI	Damage Rating Index
DRP	Division of Reactor Projects
DRS	Division of Reactor Safety
EDG	Emergency Diesel Generator
EFW	Emergency Feedwater
EPRI	Electric Power Research Institute
EOC	Extent-of-Condition
ET	Electric Tunnel
EV	Equipment Valve
FEA	Finite Element Analysis
FHWA	Federal Highway Administration
FP	Foreign Print
FPL	Florida Power and Light
FSEL	Franklin Structural Engineering Laboratory
IMC	Inspection Manual Chapter
IP	[NRC] Inspection Procedure
LF	Load Factor
MPR	MPR Associates, Inc.
NRC	Nuclear Regulatory Commission
PARS	Publicly Available Records
P&ID	Piping and Instrument Diagram
PM	Preventative Maintenance
POD	Prompt Operability Determination
PRA	Probabilistic Risk Assessment
psi	pounds per square inch
QA	Quality Assurance
RCA	Radiologically Controlled Areas
RCE	Root Cause Evaluation
RHR	Residual Heat Removal
SDP	Significance Determination Process
SG&H	Simpson, Gumpertz & Heger

SMP	Structures Monitoring Program
SRI	Senior Resident Inspector
UFSAR	Updated Final Safety Analysis Report
UT-A	University of Texas - Austin
UK	United Kingdom
WO	Work Orders

SEABROOK ALKALI-SILICA REACTION (ASR)
CONFIRMATORY ACTION LETTER (CAL) CLOSEOUT

June 24, 2013

PURPOSE:

To provide an overview of the Seabrook closeout of the CAL regarding ASR.

EXPECTED OUTCOMES:

To inform the Office of Nuclear Reactor Regulation senior management of the Seabrook ASR CAL closeout by Region I and the next steps.

PROCESS:

1. Background	Lamb	5 mins.
2. CAL Closeout	Lamb	5 mins.
3. Next Steps	Lamb	5 mins.

B126

Lamb, John

From:	Lamb, John
Sent:	Monday, June 24, 2013 11:18 AM
To:	Rodriguez, Veronica
Subject:	FW: For Your Review - POP and Slides for ASR
Attachments:	POP Briefing on CAL Closure - NRR Management - 06-24-2013.pptx; POP 06-24-2013 - Rev 4.docx
Importance:	High

Any comments? Do you want me to forward it to NRR management or make copies for NRR management?

From: Lamb, John
Sent: Monday, June 24, 2013 9:13 AM
To: Rodriguez, Veronica
Subject: For Your Review - POP and Slides for ASR

Veronica,

Attached for your review, are the POP and briefing slides for ASR.

Thanks.
John

NRR Senior Management Briefing
Seabrook ASR CAL Closure

June 24, 2013

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Tentative Schedule

June 25-28	Last week of Inspection #2 and Exit Meeting
July 2013	Issue Inspection Report #2
Aug 2013	Issue CAL Closure Letter
Sept 2013	Public Meeting with NextEra
Semi-Annual	Region I conduct PI&R sample inspection (open ODs)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Tentative Schedule

- Anticipate the licensee will submit a license amendment request (LAR) in 2015
  - Complete ASR LAR review in 2016

- Complete Seabrook License Renewal LAR review TBD

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Questions?

United States Nuclear Regulatory Commission
Protecting People and the Environment

SEABROOK ALKALI-SILICA REACTION (ASR)
CONFIRMATORY ACTION LETTER (CAL) CLOSEOUT

June 24, 2013

PURPOSE:

To provide an overview of the Seabrook closeout of the CAL regarding ASR.

EXPECTED OUTCOMES:

To inform the Office of Nuclear Reactor Regulation senior management of the Seabrook ASR CAL closeout by Region I and the next steps.

PROCESS:

1. Background	Lamb	5 mins.
2. CAL Closeout	Lamb	5 mins.
3. Next Steps	Lamb	5 mins.

Buford, Angela

From: Buford, Angela
Sent: Wednesday, June 26, 2013 12:54 PM
To: Fuhrmann, Mark
Subject: RE: Discussion of Groundwater Sampling

Mark,

Refer to the SER for Seabrook license renewal for some background on the groundwater issues at Seabrook. The discussion tomorrow will be about how, given that they have ASR on underground, continuously wetted structures (i.e., "B" electrical tunnel), they will ensure that groundwater issues will not have an added effect on the concrete. What will we accept in terms of sampling? Should the licensee sample water that has come through the concrete? Would there be any way to tell from sampling water that comes through the concrete if there is rebar corrosion?

The SER is on the public LR website http://www.nrc.gov/reactors/operating/licensing/renewal/applications/seabrook.html

---

From: Fuhrmann, Mark
Sent: Wednesday, June 26, 2013 8:53 AM
To: Buford, Angela
Subject: RE: Discussion of Groundwater Sampling

Hi Angela;
Do you have any background information I may need for this discussion?

Mark Fuhrmann, Ph.D.
Geochemist
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Mail Stop CSB 2C-07m
11555 Rockville Pike
Rockville, MD 20852-2738

mark.fuhrmann@nrc.gov
Phone: 301-251-7472
Fax: 301-251-7410

From: Buford, Angela
Sent: Wednesday, June 26, 2013 8:50 AM
To: Willoughby, Paul
Cc: Fuhrmann, Mark
Subject: RE: Discussion of Groundwater Sampling

Paul,

Can you set up a bridge line for this meeting? One of our Geochemists from headquarters will be joining the call. He is copied here.

Thanks,

B128

Angie

From: Willoughby, Paul [Paul.Willoughby@nexteraenergy.com]
Sent: Tuesday, June 25, 2013 4:10 PM
Required: Willoughby, Paul; Cook, William; Trapp, James; Floyd, Niklas; Raymond, William; Buford, Angela; Noble, Rick; Robinson, David; Vassallo, Theodore; Brown, Brian
Subject: Discussion of Groundwater Sampling
When: Thursday, June 27, 2013 10:30 AM-11:00 AM.
Where: GOB Bullpen Area - 1st Floor

Lamb, John

From: Klett, Audrey

Sent: Thursday, June 27, 2013 1:35 PM

To: Beltz, Terry; Faria-Ocasio, Carolyn; Lamb, John; Lingam, Siva; Rodriguez, Rafael

Cc: Feintuch, Karl; Saba, Farideh

Subject: Latest Rev for your review: One Pager for Eric - Mano Nazar Drop In R3.docx

One Pager for Eric - Mano Naza...

B129

Mano Nazar Drop-In with Eric Leeds on Tuesday, July 2, 2013

BACKGROUND
- Mano Nazar is the Executive VP and Chief Nuclear Officer of NextEra Energy, Inc.
- NextEra Energy, Inc. has two subsidiaries: Florida Power & Light (FPL) and NextEra Energy Resources, LLC.
- The FPL fleet consists of St. Lucie 1 & 2 and Turkey Point 3 & 4.
- The NextEra fleet consists of Duane Arnold (DAEC), Point Beach 1 & 2, and Seabrook.

REACTOR OVERSIGHT PROCESS SUMMARY
- All NextEra & FPL units are in Column 1 except:
  - Point Beach 1 is in Column 2 as of 4Q12 because of 1 white finding for inadequate work controls related to aux feed pump maintenance. IP 95001 not yet scheduled.
  - Turkey Point 3 is in Column 2 as of 1Q13 because of 1 white PI for unplanned scrams per 7000 hours. IP 95001 not yet scheduled.
- Point Beach 1 & 2 have a preliminary yellow finding related to external flooding (wave run-up not mitigated by jersey barriers). The choice letter was issued on June 17th.
- Seabrook has an open Action Matrix Deviation for increased inspection of alkali-silica reaction (ASR). NRC is inspecting CAL commitments and NextEra's ASR test program at U of Texas.

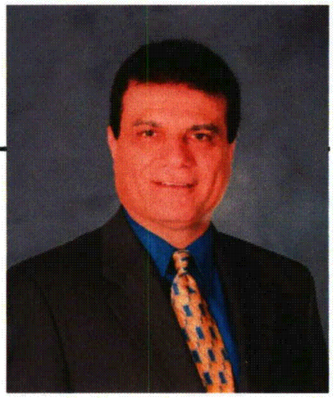
JLD/NTTF STATUS
- Priority 1 (Point Beach), Priority II (St. Lucie & Turkey Point), Priority III (Seabrook), Priority IV (DAEC)
- The first post-Fukushima seismic walkdown audit performed by NRC staff was done for Point Beach in June.
- Staff is assessing SONGS ASLB decision on CALs to determine whether to issue CALs to Turkey Point and others related to interim actions for Recommendation 2.1 Flooding Hazard Re-Evaluations.

HOT TOPICS / PUBLIC INTEREST / NEWS ITEMS
- Duane Arnold: David Lochbaum of UCS sent a letter to Iowa Governor Brandstad about DAEC's lack of compliance with fire regulations from 1980 to 2004. The Governor tasked Iowa's Dept. of Homeland Security to coordinate the Governor's response to DAEC's June 20th response to the UCS letter.
- Seabrook's ASR issues are in the news. Seacoast Anti-Pollution League challenging license renewal efforts. IAEA visited Seabrook in June for followup on its 2011 OSART.
- Turkey Point's increased oversight because of scrams and nuclear cost recovery articles are in the news.

SIGNIFICANT LICENSING ACTIONS
- NFPA 805 Transition Submittals (all but Seabrook submitted letters of intent to transition)
  - Duane Arnold's submittal is under review. NRC's due date of August 2013 will be challenged by pending RAI responses and PRA methodologies not previously approved by NRC. No NRC action.
  - Turkey Point's submittal is under review. NRC's due date is May 2014.
  - St. Lucie's application was accepted for review, and Point Beach recently submitted its application.
- Power Uprates – all approved.
  - EPUs approved for Point Beach (2011), Duane Arnold (2001), St. Lucie (2012), & Turkey Point (2012). Turkey Point had several reactor trips upon start-up after EPU.
  - Seabrook – Stretch (2005) & Measurement Uncertainty Recapture (2006) approved.
- License Renewal: Seabrook's application under review. All other units have renewed licenses.
- COL Applications: Turkey Point 6 & 7 (AP1000s) under review.

NextEra Energy, Inc.

(formerly FPL Group, Inc.)



Biographical Information

Mano K. Nazar

Executive Vice President & Chief Nuclear Officer

Mano K. Nazar is Executive Vice President & Chief Nuclear Officer at NextEra Energy, Inc. (formerly FPL Group, Inc.) (NYSE:NEE). He is responsible for the safe operation of the entire nuclear generation fleet.

Mr. Nazar joined NextEra Energy in November 2007 and is a leader in nuclear fleet excellence. Mano oversees the daily operation activities at St. Lucie, Turkey Point, Seabrook, Duane Arnold Energy Center and Point Beach nuclear power plants. In addition, he is also responsible for engineering, major projects, training, performance improvement, nuclear plant support, and major power uprate projects. He brings a unique perspective and more than 25 years of extensive nuclear industry experience.

Mano comes to us from American Electric Power (AEP) where he was senior vice president and chief nuclear officer since October 2003. Before his appointment at AEP, he was senior vice president of nuclear operations for Nuclear Management Company (NMC) where he was responsible for Westinghouse reactor sites. He also served as site vice president at the Prairie Island Nuclear Plant during his time with NMC. Prior to that, Mano held increasingly responsible positions with Duke Power Company. During his career, he has led several sites in achieving excellence performance.

Mano has a Bachelor of Science degree in mechanical engineering from the University of North Carolina at Charlotte.

Mr. Nazar serves as chairman of the Industry Nuclear Power Council Executive Committee, as well as, serves on the Institute of Nuclear Power Operations Perry Focus Oversight Board. Mano was elected as the 2006 Nuclear Professional of the Year and received the prestige 2007 WANO Nuclear Energy Award.

NextEra Energy, Inc. (which previously operated as FPL Group) is a leading clean energy company with 2009 revenues of more than $15 billion, nearly 43,000 megawatts of generating capacity, and more than 15,000 employees in 28 states and Canada. Headquartered in Juno Beach, Florida, NextEra Energy's principal subsidiaries are NextEra Energy Resources, LLC, the largest generator in North America of renewable energy from the wind and sun, and Florida Power & Light Company, which serves approximately 4.5 million customer accounts in Florida and is one of the largest rate-regulated electric utilities in the country. Through its subsidiaries, NextEra Energy collectively operates the third largest U.S. nuclear power generation fleet.

For more information about NextEra Energy companies, visit these Web sites: www.NextEraEnergy.com, www.NextEraEnergyResources.com, www.FPL.com.

Buford, Angela

From: Raymond, William NRO
Sent: Friday, June 28, 2013 8:21 AM
To: 'James Trapp'
Cc: Cook, William; Floyd, Niklas; Buford, Angela
Subject: RE: Seabrook ASR

Thanks, Jim.
Bill

From: James Trapp [mailto:james.trapp@me.com] RI
Sent: Thursday, June 27, 2013 4:31 PM
To: Cook, William
Cc: Raymond, William
Subject: Fwd: Seabrook ASR

Begin forwarded message:

From: James Trapp <james.trapp@me.com>
Subject: Seabrook ASR
Date: June 27, 2013 3:54:52 PM EDT
To: george.thomas@nrc.gov

George - we appreciate your input yesterday. Nik Floyd one of inspectors did some "back of the envelope" calculation and based on the crack widths in a pipe pen area location (based on chemical pre-stress only), the strain in the Rebar may exceed the yield. We reviewed Section III of the ASME Code, and as you told us - the code does not allow the rebar to be yielded. Is there someone with knowledge of what to do when you don't meet the code in HQ that we could talk with?

It is clear that we don't have a significant safety issue for several reasons (1) strain on surface might not reflect at the rebar, (2) the expansion may be surface shrinkage and not ASR, (3) ILRT showed containment returning to pre-existing condition. Any advice would be appreciated. Thanks

From IMC 9900 Operability Guidance

C.13 Structural Requirements

Structures may be required to be operable by the TSs, or they may be related support functions for SSCs in the TSs. Examples of structural degradation are concrete cracking and spalling, excessive deflection or deformation, water leakage, rebar corrosion, missing or bent anchor bolts, and degradation of door and penetration sealing. If a structure is degraded, the licensee should assess the structure's capability of performing its specified function. As long as the identified degradation does not result in exceeding acceptance limits

B/30

specified in applicable design codes and standards referenced in the design basis documents, the affected structure is either operable or functional.

NRC inspectors, with possible headquarters support, should review licensees' evaluations of structural degradations to determine their technical adequacy and conformance to licensing and regulatory requirements.

Lamb, John

From: Rodriguez, Veronica
Sent: Friday, June 28, 2013 1:22 PM
To: Lamb, John
Subject: RE: Three Pager for Eric re Mano Nazar Drop In

Fantastic job. Great team work!

Some edits re Seabrook for consideration. Pls review for accuracy and make any changes you deem necessary.

Three-Pager for Eric re Mano N...

From: Lamb, John
Sent: Friday, June 28, 2013 10:29 AM
To: Rodriguez, Veronica
Subject: FW: Three Pager for Eric re Mano Nazar Drop In

From: Klett, Audrey
Sent: Friday, June 28, 2013 10:27 AM
To: Beltz, Terry; Lamb, John; Faria-Ocasio, Carolyn
Cc: Saba, Farideh; Lingam, Siva; Rodriguez, Rafael; Feintuch, Karl
Subject: Three Pager for Eric re Mano Nazar Drop In

Terry, Carolyn, John,

Will your BCs want to review the three-pager before I send it up to the NRR TA?

If everyone's ok with it, I'll send it up today.

<< File: Three-Pager for Eric re Mano Nazar Drop In.docx >>

Mano Nazar Drop-In with Eric Leeds on Tuesday, July 2, 2013 @ 1 pm

BACKGROUND

- Mano Nazar is the Executive VP and Chief Nuclear Officer of NextEra Energy, Inc.
- NextEra Energy, Inc. has two subsidiaries responsible for nuclear power generation: Florida Power & Light (FPL) and NextEra Energy Resources, LLC.
- The NextEra Energy, Inc. Fleet (all units at 100% power as of June 28):

Florida Power & Light

- St. Lucie 1 & 2 (CE PWR) Near Ft. Pierce, Florida
- Turkey Point 3 & 4 (WEST 3-LP PWR) Near Miami, Florida

NextEra Energy Resources, LLC.

- Duane Arnold (DAEC) (GE4 BWR Mark 1) Near Cedar Rapids, Iowa
- Point Beach 1 & 2 (WEST 2-LP PWR) Near Green Bay, Wisconsin
- Seabrook 1 (WEST 4-LP PWR) Near Portsmouth, New Hampshire

REACTOR OVERSIGHT PROCESS SUMMARY

- All units are in Column 1 except:
  - Point Beach 1: Column 2 (4Q12) because of 1 white finding related to aux feed pump maintenance. IP 95001 not yet scheduled.
  - Turkey Point 3: Column 2 (1Q13) because of 1 white PI for unplanned scrams per 7000 hours. IP 95001 not yet scheduled.
- Point Beach 1 & 2 have a preliminary yellow finding related to external flooding (wave run-up not mitigated by jersey barriers). The choice letter was issued on June 17th.
- Seabrook has an open Action Matrix Deviation for increased inspection of alkali-silica reaction (ASR). NRC is inspecting CAL commitments and NextEra's ASR test program at University of Texas. The CAL is expected to be closed out in an inspection report to be issued in ~ July. A public meeting to discuss the CAL closeout is tentatively scheduled for September.

HOT TOPICS / PUBLIC INTEREST / NEWS ITEMS

- Duane Arnold: David Lochbaum of UCS sent a letter to Iowa Governor Brandstad about DAEC's lack of compliance with fire regulations of 1980 and 2004. The Governor tasked Iowa's Dept. of Homeland Security to coordinate the Governor's response to DAEC's June 20th response to the UCS letter. No NRC actions are planned.
- Seabrook's alkali-silica reaction issues are in the news. Seacoast Anti-Pollution League challenging license renewal efforts. IAEA visited Seabrook in June to follow-up on its 2011 OSART. At the exit meeting, the OSART team stated that all 2011 findings have been corrected or significant progress has been made. The IAEA report hasn't been issued yet.
- Turkey Point's increased oversight because of scrams and nuclear cost recovery articles are in the news. Turkey Point 3 has 4 licensee event reports in 2013 so far.

SIGNIFICANT LICENSING ACTIONS

- NFPA 805 Transition Submittals (all but Seabrook submitted letters of intent to transition)
  - Duane Arnold's submittal is under review. NRC's due date of August 2013 will be challenged by pending RAI responses and PRA methodologies not previously approved by NRC.
  - Turkey Point's submittal is under review. NRC's due date is May 2014.
  - St. Lucie's application was recently accepted for review.
  - Point Beach recently submitted its application.
- Power Uprates – all approved, recently for Point Beach, St. Lucie & Turkey Point.
- License Renewal: Seabrook's application is under review. The review was delayed due to the ASR findings. All other units have renewed licenses.
- COL Applications: NRO staff is reviewing the Turkey Point 6 & 7 (AP1000s) application.

- Exemption Requests from Point Beach, St. Lucie, & Turkey Point related to fuel cladding material.

POST-FUKUSHIMA ACTIONS STATUS

- NextEra plants have submitted all requested and required information per the orders and requests for information.

- Recommendation 2.1: Flooding Re-evaluations:
  - Category 1: Turkey Point submitted its flooding hazard evaluation by March 12, 2013. The staff is reviewing and will issue a safety assessment.
  - Category 2: Duane Arnold is to submit its evaluation by March 12, 2014.
  - Category 3: Point Beach, Seabrook, and St. Lucie are to submit their evaluations by March 12, 2015.

- Recommendation 2.1: Seismic Hazard Re-evaluations: Nothing noteworthy to report.

- Recommendation 2.3: Flooding Walkdowns: None of the NextEra plants are scheduled for a regulatory audit.

- Recommendation 2.3: Seismic Walkdowns:
  - During the week of June 17th, the NRC did a seismic walkdown audit at Point Beach. NRC focused on learning how the licensee and its contractor conducted the walkdowns. NRC preliminarily has the following concerns from the audit related to contractor practices and licensing basis evaluations.
    - A contractor practice of completing seismic walkdown checklists prior to the walkdown
    - A contractor practice of not accurately documenting the as-found condition of components
    - Inadequate licensee evaluations of as-found conditions
    - Inadequate independence in the licensee's peer review process of its contractor.
  - Seabrook's audit is scheduled the week of July 29th.

- Recommendation 4.2 (Mitigation Strategies) & 7.1 (Spent Fuel Pool Instrumentation) Orders Review Priorities:
  - Priority 1: Point Beach
  - Priority 2: St. Lucie & Turkey Point
  - Priority 3: Seabrook
  - Priority 4: DAEC

NextEra Energy, Inc.

(formerly FPL Group, Inc.)

Biographical Information

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For more information about NextEra Energy companies, visit these Web sites: www.NextEraEnergy.com, www.NextEraEnergyResources.com, www.FPL.com.

From: Raymond, William NRO
Sent: Friday, July 12, 2013 10:25 AM
To: Raymond, William
Cc: Buford, Angela; Trapp, James; Floyd, Niklas
Subject: RE: Report 201210-Containment POD - Prestress

Bill,
The earliest version of ASME III that I could find in IHS is the 1975 edition. Basically, the requirements of Division 2, CC-3400 are the same – "keep the containment below the range of general yield"... See the excerpt below.

ASME III, Division 2 , **1975** CC-3400 CONCRETE CONTAINMENT
STRUCTURE DESIGN ALLOWABLES
CC-3410 GENERAL
In order to keep the containment basically elastic under service load conditions and below the range of general yield under factored loads, the allowable stresses and strains specified in this Subarticle shall be used. The allowable stresses given in CC-3421, CC-3422, CC-3423. CC-3431, CC-3432. and CC-3433 shall not be exceeded when the containment is subjected to the loads in Table CC-3230-1.
pg **187**

This is the exact same language as in the current versions of the Code. Thus, it is likely that the code used in the Seabrook design and licensing basis (1971) would also require that the containment be kept below yield under the specified load conditions.

I am not sure it is necessary (or worth the effort) to get the 1971 edition. We have made the point to NextEra and they have agreed to address the ASR induced stresses in the steel reinforcement.
Let me know if you think I should pursue this further.
Bill

From: Raymond, William
Sent: Friday, July 12, 2013 8:23 AM
To: Raymond, William
Cc: Buford, Angela; Trapp, James
Subject: RE: Report 201210-Containment POD - Prestress

Bill,
I forget to mention in my last email that I will be researching the 1971 edition of ASME III today...
Bill

From: Raymond, William
Sent: Friday, July 12, 2013 8:21 AM
To: Raymond, William
Cc: Buford, Angela; Trapp, James
Subject: Report 201210-Containment POD - Prestress

Bill,
Here are my thoughts on possible report changes for the Containment POD & prestress.
I also included a suggestion on the section on Core Sampling – per Rick Noble, it is definite NextEra will test additional cores from Seabrook structures for material properties including compressive strength and modulus (but not tensile).

B/32

When is a good time to call to discuss?
Bill

Buford, Angela

From: Buford, Angela
Sent: Wednesday, July 24, 2013 9:31 AM
To: Cook, William
Subject: RE: Draft Seabrook ASR CAL Follow-up Report for your review

Ok, I'll make sure to have them before Friday.

From: Cook, William
Sent: Wednesday, July 24, 2013 7:51 AM
To: Buford, Angela
Subject: RE: Draft Seabrook ASR CAL Follow-up Report for your review

Thanks Angie. No hurry, I'm at Beaver Valley supporting the HQ Seismic Audit and won't be back in the office until Friday.
Bill

From: Buford, Angela
Sent: Wednesday, July 24, 2013 7:37 AM
To: Cook, William
Subject: RE: Draft Seabrook ASR CAL Follow-up Report for your review

Bill I was out of the office and missed your call on Monday – I will provide you comments by COB today.

Angie

From: Cook, William
Sent: Tuesday, July 23, 2013 5:28 PM
To: Trapp, James; Dentel, Glenn; Marshall, Michael; McMurtray, Anthony
Cc: Raymond, William; Cook, William; Buford, Angela; Floyd, Niklas
Subject: Draft Seabrook ASR CAL Follow-up Report for your review

Attached is the draft report for your early review and feedback. We would appreciate your review and comments at your earliest convenience.

Thanks,
Bill Cook

Marshall, Michael

From: Marshall, Michael
Sent: Wednesday, July 24, 2013 5:27 PM
To: Lubinski, John; Pelton, David
Subject: Correction: Second and Final Seabrook ASR CAL Inspection Report

Hello John and Dave,

In my monthly early today, I mentioned that I would be provided a copy of the second and final Seabrook ASR CAL inspection report next month for review. I received a copy via email for review, yesterday. Tony McMurtray of DE was also sent a copy to review. I plan to provide any comments that I may have early next week.

Michael

B134

Marshall, Michael

From: Marshall, Michael
Sent: Wednesday, July 24, 2013 5:32 PM
To: Erickson, Alice
Subject: REQUEST: Draft Seabrook ASR CAL Follow-up Report for your review
Attachments: IR 2012-010 draft 7-23-13.docx

Hello Alice,

Please, review the attached inspection report and provide me with any comments you may have by next Tuesday. I will review the report in parallel. If you have time before you class next week, let's plan to compare notes on Tuesday or Thursday morning.

Thanks,
Michael L. Marshall, Jr.
Chief
Aging Management of Structures, Electrical, and Systems Branch
Division of License Renewal
Office of Nuclear Reactor Regulation

301-415-2871
Email: michael.marshall@nrc.gov

From: Cook, William
Sent: Tuesday, July 23, 2013 5:28 PM
To: Trapp, James; Dentel, Glenn; Marshall, Michael; McMurtray, Anthony
Cc: Raymond, William; Cook, William; Buford, Angela; Floyd, Niklas
Subject: Draft Seabrook ASR CAL Follow-up Report for your review

Attached is the draft report for your early review and feedback. We would appreciate your review and comments at your earliest convenience.

Thanks,
Bill Cook

B135

From:	Erickson, Alice
To:	Marshall, Michael
Subject:	RE: REQUEST: Draft Seabrook ASR CAL Follow-up Report for your review
Date:	Friday, July 26, 2013 1:38:00 PM
Attachments:	IR 2012-010 draft 7-23-13 - AE comments.docx

Michael,

I've made comments through track changes in the attached file. My class starts at 8:00 am next week so we can meet at 7:00 am on Tuesday if that works for you?

Alice

From: Marshall, Michael
Sent: Wednesday, July 24, 2013 5:32 PM
To: Erickson, Alice
Subject: REQUEST: Draft Seabrook ASR CAL Follow-up Report for your review

Hello Alice,

Please, review the attached inspection report and provide me with any comments you may have by next Tuesday. I will review the report in parallel. If you have time before you class next week, let's plan to compare notes on Tuesday or Thursday morning.

Thanks,
Michael L. Marshall, Jr.
Chief
Aging Management of Structures, Electrical, and Systems Branch
Division of License Renewal
Office of Nuclear Reactor Regulation

301-415-2871
Email: michael.marshall@nrc.gov

From: Cook, William
Sent: Tuesday, July 23, 2013 5:28 PM
To: Trapp, James; Dentel, Glenn; Marshall, Michael; McMurtray, Anthony
Cc: Raymond, William; Cook, William; Buford, Angela; Floyd, Niklas
Subject: Draft Seabrook ASR CAL Follow-up Report for your review

Attached is the draft report for your early review and feedback. We would appreciate your review and comments at your earliest convenience.

Thanks,
Bill Cook

B136

ENCLOSURE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
2100 RENAISSANCE BOULEVARD, SUITE 100
KING OF PRUSSIA, PENNSYLVANIA 19406-2713

Mr. Kevin Walsh
Site Vice President
Seabrook Nuclear Power Plant
NextEra Energy Seabrook, LLC
c/o Mr. Michael Ossing
P.O. Box 300
Seabrook, NH 03874

SUBJECT: SEABROOK STATION, UNIT NO. 1 - CONFIRMATORY ACTION LETTER FOLLOW-UP INSPECTION - NRC INSPECTION REPORT 05000443/2012010

Dear Mr. Walsh:

On June 27, 2013, the U. S. Nuclear Regulatory Commission (NRC) completed a team inspection at Seabrook Station, Unit No. 1. The enclosed inspection report documents the inspection results, which were discussed with you and other members of your staff.

The team inspection examined activities conducted under your license as they relate to safety and compliance with the Commission's rules and regulations and with the conditions of your license. Specifically, the team reviewed selected procedures and records, observed activities, and interviewed station personnel regarding the adequacy of NextEra's actions to address the impact of Alkali-Silica Reaction (ASR) on reinforced concrete structures. The team reviewed selected Confirmatory Action Letter (CAL) 1-2012-002 commitments for adequacy and closure.

The NRC determined that the eleven actions committed to in CAL have been satisfactorily completed. The team independently verified that NextEra had appropriately assessed and determined that all ASR affected structures remain operable. The team also confirmed that your root cause evaluation was thorough and identified appropriate corrective actions.

Many important corrective actions necessary to resolve this issue are currently in progress. These actions include your planned two year test program of ASR affected large scale concrete specimens at the University of Texas, Ferguson Structural Engineering Laboratory (FSEL). Therefore, while our review of the CAL items was completed during this inspection, the NRC will continue to provide oversight of both NextEra's testing program at the FSEL and onsite ASR related activities. Our final decision regarding closure of the CAL will be provided to NextEra in a future correspondence.

Comment [A1]: Is DLR planning to do this, or the Region?

Comment [A2]: Why is the final decision going to be in a future correspondence? In several paragraphs, we state that the CAL items were reviewed and closed.

It should be noted that the inspection team results are based solely on Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 requirements. The NRC is currently in the process of conducting a separate review of the ASR issue as part of the license renewal process in accordance with 10 CFR Part 54. As such, certain aspects of the ASR issue discussed may also have applicability to the license renewal review and involve additional consideration and require additional information beyond that discussed in this report.

In accordance with 10 CFR 2.390 of the NRCs "Rules of Practice," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of the NRC's document system (ADAMS). ADAMS is accessible from the NRC website at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

Raymond K. Lorson, Director
Division of Reactor Safety

Docket No. 50-443
License No: NPF-86

Enclosures:
1. Inspection Report No. 05000443/2012010
   w/ Attachment: Supplemental Information
2. Confirmatory Action Letter 1-2012-002

cc w/encl: Distribution via ListServ

It should be noted that the inspection team results are based solely on Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 requirements. The NRC is currently in the process of conducting a separate review of the ASR issue as part of the license renewal process in accordance with 10 CFR Part 54. As such, certain aspects of the ASR issue discussed may also have applicability to the license renewal review and involve additional consideration and require additional information beyond that discussed in this report.

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Sincerely,

Raymond K. Lorson, Director
Division of Reactor Safety

Docket No. 50-443
License No: NPF-86

Enclosures:
1. Inspection Report No. 05000443/2012010
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U.S. NUCLEAR REGULATORY COMMISSION

REGION I

Docket No.:	50-443
License No.:	NPF-86
Report No.:	05000443/2012010
Licensee:	NextEra Energy Seabrook, LLC
Facility:	Seabrook Station, Unit No. 1
Location:	Seabrook, New Hampshire 03874
Dates:	November 3, 2012 to April 30, 2013
Inspectors:	W. Cook, Team Leader, Division of Reactor Safety (DRS) S. Chaudhary, Reactor Inspector, DRS W. Raymond, Senior Resident Inspector A. Buford, Structural Engineer, Division of License Renewal (DLR), Office of Nuclear Reactor Regulation (NRR) G. Thomas, Structural Engineer, Division of Engineering, NRR A. Sheikh, Senior Structural Engineer, DLR, NRR N. Floyd, Reactor Inspector, DRS
Approved by:	James Trapp, Chief, Engineering Branch 1 Division of Reactor Safety

SUMMARY OF FINDINGS

IR 05000443/2012010; 11/03/2012 - 06/27/2013; Seabrook Station, Unit No. 1; Confirmatory Action Letter (CAL) Follow-up Inspection Report.

This report covered several weeks of onsite inspection at Seabrook Station, two weeks of inspection at the Ferguson Structural Engineering Laboratory (FSEL) University of Texas – Austin, and periodic in-office reviews, over the past eight months, by region based inspectors and headquarters reviewers to assess the adequacy of actions taken by NextEra to address the occurrence of Alkali-Silica Reaction (ASR) in reinforced concrete structures at Seabrook Station. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process," Revision 4, dated December 2006.

Comment [A3]: Recommend using the same wording from the cover letter (highlighted) for consistency.

Cornerstone: Mitigating Systems

During this second CAL follow-up inspection, the team examined the remaining six commitments documented in CAL No. 1-2012-002, dated May 16, 2012. The CAL items reviewed and closed during this inspection were 2, 4, 7, 8, 9 and 11. In addition, a number of observations documented in the first CAL follow-up inspection (NRC Inspection Report 05000443/2012009, Section 9.0) were reviewed and closed in this report. Closure of CAL Item 7 was administrative, in that, NextEra had withdrawn this commitment by letter dated December 13, 2012 (ML12362A323). NextEra's revision to this commitment was approved by the NRC as documented in the CAL revision letter, dated January 14, 2013 (ML13014A555). Our assessment of CAL Item 7 and the remaining CAL items reviewed and closed are documented in the enclosed inspection report.

The review and closure of each CAL item signifies the NRC's satisfactory assessment of NextEra's commitments and planned corrective actions to address the non-conforming alkali-silica reaction in Seabrook reinforced concrete structures. However, the completion of the CAL follow-up inspections is not the completion of NRC review and oversight of NextEra's actions to address the ASR issue. As discussed in the team's review of CAL Item 4 and the revised ASR Project Corrective Action Plan (CAP), NextEra has implemented a number of ongoing activities, in addition to the FSEL testing program to address ASR-affected structures. The details of the NRC's plans to oversee these activities will be addressed separately.

Comment [A4]: Recommend deleting, or adding the word "condition,"

Comment [A5]: ??? We don't have detailed plans to do this, do we?

NextEra's root cause evaluation (CAL Item 2) appropriately identified the significant causal and contributing factors resulting in ASR impacting reinforced concrete structures at Seabrook Station. NextEra's ASR Project CAP (CAL Item 4) sufficiently captures the numerous corrective actions taken and planned to address the ASR non-conforming condition, and remains a "living document" to track the resolution of ASR at Seabrook Station.

Mortar Bar Testing (CAL Item 6, reference NRC Inspection Report 05000443/2012009) was successfully completed and the results indicated sufficient reactive silica and alkali in the Seabrook structures to fuel the progression of ASR for the foreseeable future. Consequently, NextEra withdrew their commitment for Prism Testing (CAL Item 7) and the NRC staff administratively closed this commitment. The team reviewed NextEra's large specimen testing program technical specifications (CAL Item 8) and anchor testing program description (CAL Item 11) and concluded that these programs were sufficiently developed and described to support an appropriate understanding of the testing plans and objectives.

NextEra implemented a number of enhancements to the Structures Monitoring Program (CAL Item 9) to adequately monitor the progression of ASR, pending the completion and evaluation of results from the large specimen testing program. The team concluded these monitoring actions were consistent with currently available industry practices.

Lastly, the team reviewed and closed a number of observations discussed in the first CAL Follow-up Inspection, including: pending structural evaluations (13); containment POD observations; core sample material property testing; quantification of pre-stressing effects of ASR expansion; additional rebar examinations; crack indexing use in the SMP; and Phase 3 walkdown plans and schedule.

REPORT DETAILS

1.0 Background

Alkali-Silica Reaction (ASR) is a chemical reaction occurring in hardened concrete that can change the physical properties of concrete and affect structural performance. In June 2009, NextEra identified potential degradation in below-grade concrete structures at Seabrook. In August 2010, NextEra completed petrographic evaluation of concrete core samples, which confirmed ASR as the degradation mechanism. The degraded condition in numerous Seabrook Category I structures was evaluated in the Corrective Action Program via prompt operability determinations (PODs). The PODs were revised as new information became available and improved analytical techniques were incorporated.

NextEra initially used the results of mechanical testing of concrete cores to assess the degree of structural degradation due to ASR. This is a traditional method described in American Concrete Institute (ACI) 228.1R, "In-Place Methods to Estimate Concrete Strength," for assessing existing concrete structures. NextEra tested the cores for compressive strength and elastic modulus. NextEra used the methods defined in construction and design code ACI 318-1971, "Building Code Requirements for Reinforced Concrete," to evaluate the structural capacity (operability) of the ASR-affected structures. However, the mathematical relationships in ACI-318 are based on empirical data from testing of non-degraded concrete, and these relationships may not be valid for ASR-affected concrete.

After further review of industry experience and literature pertaining to ASR, NextEra engineering concluded that the core test data was not indicative of structural performance of ASR-affected reinforced concrete structures. NextEra's engineering evaluation stated that once the cores are removed from the structure, concrete core samples are no longer subject to the strains imposed by the ASR-related expansion or restraints imposed by the steel reinforcing cage. The engineering evaluation also stated that confinement provided by steel reinforcing bars (rebar) and other restraints limit ASR expansion of the concrete within the structure and thereby limit the adverse impact on structural performance. Therefore NextEra engineering concluded that the reduction of mechanical properties observed in mechanical testing of cores was not representative of in-situ concrete performance. Based on this conclusion, NextEra suspended taking core samples to evaluate the concrete mechanical properties of structures impacted by ASR and revised the operability assessment approach. NextEra's current approach for assessing structural integrity and operability is to compare available design margins to an assumed reduction in structural capacity due to ASR.

NextEra's operability evaluations were based upon an examination of available design margins and a presumed ASR-caused reduction in structural design capacity for critical limit states. The details of this methodology and related assumptions were developed in NextEra's Interim Assessment (FP 100716). The assessment assumed lower bound values of structural capacity for ASR-affected concrete for limit states based on research test data, primarily from small scale test specimens. The assessment focused on the structural limit states that are the most sensitive to ASR effects (i.e., out-of-plane shear capacity, lap splice development length, and anchorage capacity). The assessment determined the structures were suitable for continued service. A final operability assessment will be conducted by NextEra following evaluation of structural performance based on a proposed large scale testing program of beam specimens representative of Seabrook reinforced concrete structures. The test program has been initiated at the Ferguson Structural Engineering Laboratory at the University of Texas at Austin (UT-A), with some testing (anchors) commenced in 2013 and large beam testing scheduled to be completed by 2015. Based upon the slow progression of the ASR expansion, the current operability evaluations, coupled with the Structures Monitoring Program six-month combined crack indexing, provide reasonable assurance of continued structural operability until the testing program is completed.

2.0 Confirmatory Action Letter 1-2012-002

Confirmatory Action Letter 1-2012-002, dated May 16, 2012, was written to confirm commitments by NextEra (established during a meeting with NRC management and staff on April 23, 2012) with regard to planned actions to evaluate ASR-affected reinforced concrete structures at Seabrook Station. In response to the CAL, NextEra committed to provide information to the NRC staff to assess the adequacy of NextEra's corrective actions to address this significant condition adverse to quality. CAL 1-2012-002 is provided as an Enclosure to this report. The NRC staff also formed a working group to provide appropriate oversight of NextEra's activities to address ASR and to coordinate NRC inspection and review activities. The ASR Working Group Charter (ML121250588) outlines the regulatory framework and general acceptance criterion for NRC oversight and review of this issue. As documented in NRC Inspection Report No. 05000443/2012009, dated December 3, 2012 (ML12338A283) CAL Items 1, 3, 5, 6, and 10 were closed.

Based on the results of this inspection, the remaining six CAL Items 2, 4, 7, 8, 9, and 11 are closed.

3.0 Review of Alkali-Silica Reaction Root Cause Evaluation (CAL Item 2)

Inspection Scope

As documented in Inspection Report No. 05000443/2012009, the team reviewed NextEra's response to CAL Item 2, "Submit the root cause for the organizational causes associated with the occurrence of ASR at Seabrook Station and related corrective actions by May 25, 2012." The licensee submitted their root cause evaluation (RCE) in a letter to the NRC dated May 24, 2012 (ML12151A396). Based upon the team's initial review, the inspectors concluded that the second root cause identified was not sufficiently characterized in NextEra's May 24, 2012, submittal. Specifically, NextEra did not clearly describe the personnel and organizational factors that contributed to inadequacies in the Structures Monitoring Program (SMP) and the failure of the Seabrook staff to have identified ASR degradation of reinforced concrete structures sooner. The team discussed this observation with the responsible Seabrook staff and NextEra determined that a revision to the RCE was warranted and revised the RCE to more appropriately develop and characterize this second root cause and the associated corrective actions.

NextEra submitted a revised RCE summary for NRC review in a letter dated May 1, 2013, (ML13151A328, Enclosure 1). The team reviewed the revised RCE summary for clarity and appropriateness of associated corrective actions, consistent with guidance outlined in 10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Action," and NextEra's Corrective Action Program (CAP).

Findings and Observations

The team identified no findings. Based upon the team's review, CAL Item 2 is closed.

As documented in Enclosure 1 to the May 1, 2013 letter, NextEra summarized the two root causes, as follows: RC1 – the ASR developed because the concrete mix design unknowingly utilized a coarse aggregate that would, in the long term, contribute to ASR. Although the testing was conducted in accordance with American Society for Testing and Materials (ASTM) standards, those testing standards were subsequently identified as limited in their ability to predict slow reactive aggregate that produced ASR in the long term; and RC2 – based on the long standing organizational belief that ASR was not a credible failure mode due to the concrete mix design, dispositions for Condition Reports involving groundwater intrusion or concrete degradation, along with the structures health monitoring program did not consider the possibility of ASR development. In addition, NextEra identified a contributing cause involving the failure of the organization to prioritize groundwater elimination or mitigation resulting in more concrete area exposed to moisture.

The team verified that NextEra had appropriately identified the root cause(s). The ASTM concrete aggregate testing standards in effect at the time of plant construction were properly implemented, but later determined to be ineffective in identifying slow reacting, ASR susceptible aggregates. Those standards were subsequently revised by the industry and adopted by NextEra to prevent recurrence. NextEra's RCE concluded that the Structures Monitoring Program (SMP) did not remain current with concrete industry operating experience and associated failure modes, such as ASR. Contributing to the shortcomings in the SMP to have identified this concrete degradation mechanism earlier was the "organizational mindset" that the groundwater in-leakage was an operational nuisance and nothing more. Consequently, station and engineering staffs were insensitive to the potential detrimental effects of the ground water infiltration and did not assess the long term impact on station structures. The team concluded that NextEra's implementation of a broad periodic review process to ensure all systems and component monitoring programs remain current and effective was determined an appropriate corrective action for this causal factor.

4.0 Integrated Corrective Action Plan (CAL Item 4)

Inspection Scope

CAL No. 1-2012-002 documented NextEra's commitment to submit by June 8, 2012, a corrective action plan for the continued assessment of ASR in concrete structures at Seabrook Station including development of remedial actions to mitigate the effects of ASR, where warranted. By letter dated June 8, 2012 (ML12171A227), NextEra submitted their integrated corrective action plan (CAP) for NRC review. The CAP outlined the major elements of diagnosis, evaluation, prognosis and mitigation of ASR-affected structures as understood at the time. Since June 8, 2012, NextEra has made considerable progress in refining the elements of this plan, implementing the initial phases, and more clearly defining and focusing future actions. NextEra provided an updated ASR Project CAP in a letter dated May 1, 2013 (ML13151A328, Enclosure 2) to document these plan changes.

During this inspection period, the team conducted numerous discussions, meetings, and conference calls with NextEra, as well as onsite inspections at both Seabrook Station and UT-Austin to review NextEra's actions to address the ASR-affected reinforced concrete structures. From these interactions, the CAP has developed greater clarity of the necessary steps (corrective actions) to address this non-conforming condition impacting safety-related reinforced concrete structures. As previously documented in Inspection Report 05000443/2012009 and detailed in other sections of this report, the team assessed the adequacy of completed and ongoing ASR-related activities identified in the integrated CAP, consistent with guidance outlined in 10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Action," and NextEra's Quality Assurance Program.

Findings and Observations

The team identified no findings. Based upon the team's review, CAL Item 4 is closed. NextEra's ASR project staff stated that they plan to maintain the ASR Project CAP as a "living document" and will update it periodically to capture completion of activities and add new actions, as appropriate.

5.0 Prism Testing Commitment Withdrawn (CAL Item 7)

Inspection Scope

CAL Item 7 committed NextEra to "Complete long term aggregate expansion testing (ASTM C 1293, Concrete Prism Test) by June 30, 2013." The purpose of this CAL item was to determine, in conjunction with the Mortar Bar Testing (CAL Item 6), if the coarse aggregate contributing to ASR in Seabrook reinforced concrete still contained sufficient reactive silica for the alkali-silica reaction to continue long-term under the existing environmental conditions. Alternatively, these tests could demonstrate that the progression of ASR at Seabrook maybe self-limiting due to the depletion of reactive silica in the concrete. The Prism Test (as defined by ASTM C1293) involves monitoring the expansion (by measurement of specimen elongation due to ASR) of the test specimen (a molded concrete brick approximately 3 by 5 by 12 inches in length) over a one year period. Expansion in excess of 0.04% is considered potentially deleterious and a positive test for slow reactive aggregate. The Prism Test is similar to the Mortar Bar Test (reference ASTM C1260), but has a duration of 14 days and an expansion limit of 0.1%.

Based upon the results of the completed Mortar Bar Expansion Testing (reference NRC Inspection Report No. 05000443/2012009, Section 5.0), NextEra concluded that the available quantities of silica in the concrete would not be depleted in the near term and that additional confirmatory testing via the Prism Test method was not warranted. NextEra ran the Mortar Bar Test several weeks beyond the 14-day test (terminated after 103 days) and observed that the alkali-silica reaction was still progressing at the conclusion of the test, indicating the presence of sufficiently reactive aggregate to maintain ASR for a longer period of time. The team noted that the Mortar Bar Test involved the reuse of aggregates from Seabrook test cores (concrete that had already experienced appreciable ASR) and similar aggregate from concrete not affected by ASR. The side-by-side comparison of the test specimens showed no appreciable difference in ASR progression or observed expansion rates. Accordingly, NextEra concluded the Prism Test would add no significant knowledge to the condition assessment of Seabrook concrete. NextEra concluded that all Seabrook reinforced structures are or may be affected by ASR, unless specifically ruled-out by further analysis, such as petrographic examination. By letter dated December 13, 2012, NextEra requested that CAL Item 7 be deleted. As documented in NRC letter dated January 14, 2013 (ML13014A555), the NRC accepted NextEra's technical basis for deleting CAL Item 7.

Findings and Observations

No findings were identified. CAL Item 7 is administratively closed.

6.0 Review of Technical Details of Large Specimen Testing Program (CAL Item 8)

Inspection Scope

CAL Item 8 committed NextEra to "Submit the technical details of the testing planned at the contracted research and development facility by June 30, 2012." By letter dated June 21, 2012, (ML12179A281) NextEra submitted the Shear and Lap Splice Testing overview prepared by the Ferguson Structural Engineering Laboratory (FSEL) at the University of Texas at Austin, dated March 15, 2012. The purpose of the test program, as described in the FSEL document, is to provide sufficient data and insights to establish the current and future implications of ASR on Seabrook reinforced concrete structures. Based upon limited available literature or test data relative to the impact of ASR on walls without transverse reinforcements (the majority of Seabrook ASR-affected structures) destructive testing of ASR-affected test specimens will be conducted to evaluate the impact of ASR on out-of-plane shear strength and lap splice development. The test specimens being prepared at FSEL will be of representative scale and design, such that the test results may be correlated to Seabrook structures.

The team reviewed the June 21, 2012 submittal and conducted a conference call on December 18, 2012, with the NextEra and UT-Austin FSEL staff to discuss the merits of the proposed test program. Based upon the complexity of the information discussed and follow-up inspection activities, NextEra prepared a test program overview document and a detailed test specification to supplement the June 21, 2012, CAL response letter. By letter dated May 1, 2013 (ML13151A328 redacted and ML13151A291 un-redacted) NextEra provided the NRC with the "Seabrook Station - Specification for Shear and Reinforcement Anchorage Testing of ASR-Affected Reinforced Concrete," (Enclosures 3 & 4) and "Approach for Shear and Reinforcement Testing of Concrete Affected by Alkali Silica Reaction," (Enclosure 5 & 6). Each of these documents has a proprietary and non-proprietary version.

The team reviewed the revised testing specification and the associated overview document to verify that the overall test program approach and application of test results would reasonably address the Seabrook ASR-affected concrete non-conforming condition. The team discussed the test program with the FSEL, MPR and responsible NextEra engineering staffs.

Findings and Observations

No findings were identified. Based upon team review of the submitted testing program documents and related inspection activities, the team concluded that NextEra has provided a satisfactory explanation of the proposed large-scale specimen testing program, and CAL Item 8 is closed.

The team concluded that NextEra's approach has technical merit. However, as documented in NextEra's ASR Project CAP (ML 13151A328, Enclosure 2) the acceptance of the testing results to resolve ASR concerns associated with design basis structural calculations will follow the regulatory process for approval and will include evaluations pursuant to 10 CFR 50.59 and 10 CFR 50.90. As stated above, the submitted test plans satisfy NextEra's commitment to explain the scope and depth of the large-scale specimen testing program.

7.0 Review of Structures Monitoring Program (CAL Item 9)

Inspection Scope

CAL Item 9 committed NextEra to implement an update to the Maintenance Rule (10CFR50.65) Structures Monitoring Program (SMP) to include monitoring requirements for selected locations in areas that exhibit ASR by July 15, 2012. NextEra issued Revision 2 to Structural Engineering Standard 36180, "Structural Monitoring Program," effective July 12, 2012. The primary changes incorporated in Revision 2 to the SMP were: 1) performing periodic (every six months) crack indexing measurements at 26 locations to collect quantitative information on the progression of ASR expansion/degradation; 2) establishing crack width (1.0 mm or greater) and Combined Crack Index (1.0 mm/m or greater) thresholds for conducting structural evaluations (reference Foreign Print 100716, Seabrook Station: Impact of ASR on Concrete Structures and Attachments); and 3) the addition of Federal Highway Administration (FHWA) document FHWA-HIF-09-004, "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction in Transportation Structures," dated January 2010, as a reference.

The team reviewed the adequacy of these changes to the SMP to monitor ASR in Seabrook reinforced concrete structures. While not endorsed by the NRC or committed to by NextEra in Seabrook's licensing basis, the team used the American Concrete Institute (ACI) Committee Report 349.3R-96, "Evaluation of Existing Nuclear Safety-Related Concrete Structures," as a reference to assess the adequacy of the revisions made to the SMP for monitoring the progression of ASR.

Based in part on NRC observations, NextEra issued Revision 3 to the SMP on April 30, 2013. The principle changes in Revision 3 of the SMP are: 1) the addition of periodic (every 30 months) combined crack indexing (CCI) measurements at 72 discrete locations identified as Tier II (Acceptable with Deficiency) areas (CCI values between 0.5 mm/m and 1.0 mm/m, or crack widths greater than 0.2 mm, but less than 1.0 mm) to collect quantitative information on the progression of ASR expansion/degradation (this monitoring was being performed, but not documented in the SMP); and, 2) inclusion of the periodic ground water sampling program for monitoring of chemical attributes detrimental to concrete structures. During follow-up discussion with the NextEra staff, the team noted that NextEra is considering additional SMP revisions, dependent upon the results of the large specimen test program and further engineering evaluation. One of the revisions involves the installation of deep pins for monitoring of expansion in the out-of-plane direction (reference NextEra's May 1, 2013, Response to Confirmatory Action Letter (ML13151A328) Enclosure 2, ASR Project Corrective Action Plan).

Findings and Observations

The team identified no findings in this area. CAL Item 9 is closed.

The team noted that changes made to the SMP to address ASR were generally consistent with the evaluation and monitoring methods outlined in ACI 349.3R-96. The team confirmed that NextEra had incorporated a three-tiered visual inspection criteria, as outlined in Sections 5.1 through 5.3 of ACI 349.3R-96. NextEra has also augmented this visual inspection criteria with periodic (six-month and 30-month interval) CCI measurements and associated structural evaluation thresholds based upon direct measurement (CCI) results. The CCI monitoring, performed at 98 selected locations (including containment) was implemented by NextEra based upon this method being a readily measurable indicator of ASR related progression and based, in part, upon endorsement by FHWA and outlined in FHWA-HIF-09-004.

The crack growth monitoring provides a visual indication of the progression of ASR within a reinforced concrete structure. The relative width and number of visible cracks may be correlated to the overall progression of ASR and may be used to evaluate ASR impact on structural performance. However, ASR cracking and crack propagation is closely associated with the specific reinforcement design and structural loading. Accordingly, the adequacy of CCI measurement as a long term structures monitoring methodology for Seabrook structures is being further evaluated by NextEra as part of the UT-Austin FSEL testing program. The results of the UT-Austin testing program is intended to be used to validate this methodology for application at Seabrook.

Evaluation of infiltration water chemistry and groundwater monitoring: ACI 349.3R-96 discusses environmental monitoring and related effects of aggressive water chemistry, including the potential for leaching. Accordingly, NextEra has integrated the periodic monitoring of ground water chemistry into the SMP (reference Revision 3, dated 4/30/2013, Attachment 4). NextEra plans to investigate the expansion of the water chemistry monitoring program (reference AR No. 1758920-40) to include periodic analysis of infiltrated water (water that has migrated through below grade reinforced concrete walls). The establishment of an initial baseline analysis and continued periodic monitoring could provide some relative trend data for further evaluation and follow-up actions, as appropriate.

The team concluded that the implemented and planned SMP enhancements provide NextEra with an improved program to assess the extent and degree of ASR progression and to more thoroughly monitor the environmental factors contributing to ASR. **NextEra's initial SMP revision (Revision 2) was adequate; however, the SMP Revision 3 enhancements include multiple activities that are better aligned with ACI 349.3R guidance.**

Comment [A6]: I don't think it's necessary to find a prior version of the SMP adequate.

8.0 Review of Anchor Testing Program (CAL Item 11)

Inspection Scope

The micro-cracking caused by ASR may adversely impact the structural capacity of anchors that support safety-related piping, cable trays and other components. NextEra's initial operability determinations were supported by anchor performance testing conducted on available ASR degraded specimens previously fabricated at or obtained by FSEL, UT-Austin (reference FP 100718). As documented in Inspection Report 05000443/2012009, the initial testing demonstrated satisfactory performance of the anchors in ASR-affected concrete during the earlier stages of ASR progression. NextEra's evaluation also stated that the eventual reduction in capacity due to ASR was sufficiently offset by established anchor manufacturer's design margins (FP 100716). However, based upon the limitations of the testing performed (on ASR-affected test specimens of different composition and compressive strength than Seabrook reinforced concrete structures) NextEra planned to conduct additional testing. The planned testing involves anchors installed (both during specimen fabrication and post-fabrication) in ASR-affected test specimens that more closely replicate the reinforced concrete structures and anchor configurations at Seabrook.

By licensee letter dated December 13, 2012, (ML12362A323) NextEra requested a revision to CAL Item 11 to address a schedule challenge to the targeted anchor testing program completion date. NextEra also proposed redefining CAL Item 11 to be consistent with the wording of CAL Item 8, regarding large-scale specimen testing. Specifically, NextEra revised their commitment to read, "Submit technical details of the anchor test program planned at the contracted research and development facility by February 28, 2013." The original commitment read, "Complete anchor test program by December 31, 2012. Results will be available for NRC review approximately 30 days after testing is complete." Based upon unexpected specimen fabrication delays and the slow progression of accelerated ASR aging, NextEra identified that it would not be possible to complete the anchor testing per the original commitment date. The NRC accepted NextEra's revised commitment, as documented in NRC letter dated January 14, 2013 (ML13014A555).

The team reviewed the details and adequacy of NextEra's anchor testing program as outlined in the proprietary "Anchor Testing Program Overview," dated February 26, 2013. The anchor testing program overview and associated testing specifications were docketed for NRC review via NextEra letter dated February 28, 2013 (ML13088A218 redacted and ML13088A229 un-redacted, dated March 15, 2013). The technical overview document and accompanying specifications outline the major elements of the proposed anchor testing program, including the key attributes of the fabrication of the test specimens, monitoring of the specimens as accelerated ASR aging progresses, and the details of the testing of individual anchor bolt configurations.

Findings and Observations

The team identified no findings. Based upon the team's review, CAL Item 11 is closed.

During the team's visits to the UT-Austin FSEL, the team observed the conditions and controls implemented for the aging of the test blocks and testing of concrete sample cylinders for compressive strength and modulus of elasticity. The team witnessed appropriate implementation of the testing procedures by FSEL staff and proper oversight of these activities by the MPR quality assurance staff.

At the conclusion of this inspection, the desired level of ASR progression in the test blocks had not been achieved to conduct the first round of ASR-affected anchor testing. The team reviewed the results of the control specimen anchor testing completed in November 2012. The purpose of the control specimen testing was to establish a baseline to determine the potential reduction in anchor bolt capacity due to ASR. Review of the test data (reference MPR Memorandum DRN 0326-0058-163, dated June 18, 2013) identified that all anchor bolts test results were in agreement with calculated capacities and an appropriate baseline had been established for comparison during future testing.

9.0 Review of Previously Identified Issues of Interest

9.1 Structural Evaluations for 13 Locations

As documented in Inspection Report 05000443/2012009, NextEra identified 26 locations (including containment) as having patterned cracking with a CCI of greater than 1.0 mm/m. In accordance with the SMP, Revision 2, structures with a CCI of >1.0 mm/m require a structural evaluation. NextEra's Interim Assessment documented an engineering judgment that biased the performance of detailed structural evaluations to the 11 locations with a CCI > 1.5 mm/m. The locations with a CCI of between 1.0 and 1.5 mm/m (13 locations) were considered bounded by the 11 areas subjected to a detailed evaluation. The lack of a documented structural evaluation for the 13 locations with a CCI of between 1.0 and 1.5 mm/m was a minor performance deficiency which NextEra entered into the Corrective Action Program (AR 1804477 and AR 1819080). During this inspection, the team reviewed Calculation C-S-10168, Revision 1, and FP 100716, "Seabrook Station: Impact of Alkali-Silica Reaction on Concrete Structures and Attachments," Revision 2, which incorporated the additional evaluations for the 13 locations.

Comment [A7]: Recommend referencing Revision 3 instead of Revision 2.

The evaluation methodology included reviewing the original calculations that govern the design of the structures to determine the design parameters associated with the general area of ASR degradation. The structural member's load demand and capacity were then noted and the margin calculated for comparison against the potential reductions in load capacities caused by ASR. The assumed reductions in capacity were determined based on lower bound values established in industry literature. A summary of the evaluation results was provided in Table 3 of FP100716, Revision 2. For areas where design margins were insufficient to offset assumed reductions, further review was performed to recapture margin. Specifically, for two areas (Electric Tunnel and Discharge Structure), the design calculation used conservative load factors which were lowered to establish more representative demand loads, as described in Calculation C-S-1-10168, Revision 1. NextEra demonstrated additional margin to assure structural integrity despite the assumed reduction in capacity due to ASR. However, in the calculation for Electric

Tunnel area MF101 (C-S-1-10168, pg 30), NextEra reduced the hydrostatic load factor (1.4) to achieve a more realistic load demand. NextEra plans to credit the 1.4 load factor in the load demand calculation to establish full qualification per the Final Safety Evaluation Report (FSAR) licensing basis in the final operability determination, following completion of the testing program at UT-Austin.

The team concluded that NextEra's initial approach to perform a bounding analysis for areas with CCI >1.5 mm/m was not conservative, because the design margins vary in each structural member of each reinforced concrete structure. This conclusion highlights the need, once the impact of the ASR degradation on structural capacities is determined from the UT-Austin FSEL test program, for NextEra to closely review the design calculations for each ASR impacted area to assure margins remain acceptable without having to remove or reduce the load factors assumed in the current licensing basis.

9.2 Review of Core Sample Material Property Testing

As documented in Inspection Report 05000443/2012009, Section 3.2.9, the NRC planned to reexamine the need of additional core sampling of Seabrook structures for the purpose of monitoring and assessing the condition of ASR-affected reinforced concrete. For the long term, NextEra has elected to evaluate structural performance (operability) of the Seabrook ASR-affected reinforced concrete structures by developing a testing program involving large specimens that are fabricated to closely replicate the Seabrook concrete and reinforcement design. NextEra has pursued this method, instead of conducting detailed material properties testing of core samples, based upon available laboratory testing and data that indicates that measurable material properties of removed cores do not, under all circumstances, accurately represent the "in situ" mechanical properties of the concrete. The reason for the difference is that prior to removal of the core sample, that concrete specimen was subjected to the specific structural compressive stresses (dead loads, live loads, and hydrostatic loads) and reinforcement bar restraints of its location within the structural member. When removed from the structural member, that concrete specimen is wholly unrestrained. In addition, as identified in the associated core sampling standard (ASTM C42, "Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete") core sample test results may be "....affected by many factors such as the strength level of the concrete, the in-place temperature and moisture histories, the degree of consolidation, batch-to-batch variability, the strength-gain characteristics of the concrete, the condition of the coring apparatus, and the care used in removing cores."

Team review of this issue has identified two general approaches to gaining an informed understanding of the impact of ASR on reinforced concrete structures. **One approach is that being taken by NextEra to assess the overall structural performance of an ASR-affected structural member, much like (but not the same) as the performance of a load test prescribed by ACI 318, "Building Code Requirements for Structural Concrete," Chapter 20, "Strength Evaluation of Existing Structures**." Whereas, the alternative approach involves analytical evaluations using as an input the measureable steel and concrete material property values derived from samples from the affected structure, also recognized by ACI 318, Chapter 20. NextEra is challenged to appropriately correlate the test program results to the Seabrook structures. Accordingly, NextEra plans to take additional core samples from both the test

Comment [A8]: Is it necessary to compare the Seabrook approach to the recommendations described in Chapter 20 of ACI 318?

specimens and the Seabrook structures to better correlate the large specimen test results using petrography and mechanical testing.

9.3 Containment Prompt Operability Determination (POD) and Pre-stressing Effects of ASR

As discussed in Inspection Report 05000443/2012009, the team noted that the confinement provided by the steel reinforcement bar (rebar) cage restrains ASR expansion resulting in ASR-induced or "chemical" pre-stressing of affected structural members. The team observed that NextEra had provided a qualitative explanation of this condition in the Interim Assessment (FP 100716), and in the containment structural evaluation and prompt operability determination (POD) (AR 1804477). The team concluded that a quantitative evaluation of this condition may be warranted to address this aspect of the non-conforming ASR condition.

During this inspection, the team discussed the impact of ASR-induced pre-stressing on reinforced concrete structures with NextEra's ASR Project Team and reviewed NextEra's assessment in AR/POD 1804477. The effect of "chemical" pre-stressing is to both increase the compressive stresses in the concrete (within the rebar cage) and to increase the tensile stresses in the rebar, as long as the rebar cage restraint is sustained. Similar to fabricated pre-stressed concrete structural members, the ultimate load carrying capacity of the reinforced member is not significantly changed by the ASR-induced pre-stress. Due to pre-stressing the load sharing between the concrete and steel reinforcement bars is altered, resulting in a stiffer structure that replicates a member fabricated with higher compressive strength concrete and steel reinforcements that functions closer to established yield limits. The team concluded that the ASR-induced pre-stressing may result in some beneficial effects in terms of structural stiffness, but agreed with NextEra's engineering evaluation that this additional structural stiffness, cannot be credited for structural design purposes. Further, ASR conditions may result in the steel reinforcement strain limits being exceeded that could challenge the structural performance of the rebar.

The team noted that NextEra had not quantified the ASR induced stresses in the concrete reinforcement. The team also noted that although the crack index had been measured at three containment locations, absent quantitative analyses, NextEra has not shown that the containment reinforcement was below yield. Further, the team noted that the current design code for containment (ASME Section III, 1971) does not allow containment reinforcement strains to be above yield "......in order to keep the containment basically elastic under service load conditions and below the range of general yield under factored primary loads, the allowable stresses and strains in this subsection shall not be exceeded."

The team noted, based on measured CCI data, that it may be possible for strains in containment reinforcement to be above yield. However, this condition is not certain absent a definitive correlation between the containment CCI values and stress/strain in the rebar. This matter was discussed with NextEra representatives who stated actions would be taken (reference AR/POD 1804477) to determine the effects of ASR relative to the containment design code requirements.

The team concluded that was no significant safety concern with reinforcement strain at this time because: (1) the containment is heavily reinforced and ASR is highly localized affecting a small percentage of containment area; (2) the concrete stain (crack index) measured at the surface might not reflect the condition of the reinforcement; (3) the expansion noted at the containment location with highest crack index (mechanical penetration room, 270 degree azimuth) may be surface shrinkage and not ASR, based upon the absence of confirmatory petrography; and, (4) the integrated leak rate test in 2010 showed the containment returing to preesisting conditions. See Section 9.6 of this report, "Planned Regulatory Actions," which describes NextEra's plans to address the containment non-conforming condition within the corrective action program.

Comment [A9]: I think this statement may give the wrong impression, i.e., if they were to perform a petrographic examination and confirm ASR, would there be a significant safety concern?

9.4 Assessment of the Need for Further Rebar Examinations

As documented in Inspection Report 05000443/2012009, Section 3.2.9, the NRC reviewed the potential for ASR having an adverse impact on rebar. NextEra and their engineering consultants had concluded that rebar is unaffected by ASR-degraded concrete unless the cover concrete is severely damaged and the rebar is exposed. They concluded that in spite of the alkali-silica reaction, ample alkali would remain in the concrete to preserve the condition of the rebar and preclude a corrosive environment.

The team determined that NextEra's position was acceptable. Based upon the examination of Seabrook rebar, although limited, and review of available industry operating experience associated with reinforced concrete degradation mechanism, the team concluded that at the current level of ASR there is no evidence to suggest that the reinforcing steel bars at Seabrook are corroding. In accordance with the Seabrook SMP and their referenced American Concrete Institute 349.3R-96, "Evaluation of Existing Nuclear Safety Related Concrete Structures," periodic visual inspections (signs of leaching, staining, spalling and popouts) coupled with soil and groundwater testing for aggressive chemistry conditions (chlorides, sulfates and pH) provide appropriate monitoring and industry recommended detection methodology. Inspections conducted have not identified any iron oxide staining attributed to rebar corrosion on any ASR-affected concrete structures at Seabrook. Consequently, the team has concluded that no additional rebar examinations (removing the cover concrete to expose rebar for visual inspection) are currently warranted.

Comment [A10]: What does this mean? Recommend clarification.

9.5 Use of Combined Crack Indexing for Structures Monitoring Program

As previously documented in Inspection Report 05000443/2012009, Section 6.0, the team planned to examine NextEra's basis for using Combined Crack Indexing (CCI) as the primary SMP method to monitor the progression of ASR in Seabrook structures. The team noted that the basis for NextEra's selection of CCI for monitoring, as endorsed by the FHWA, is that CCI provides a direct visual and measurable method for the detection and monitoring of ASR progression. Although the objective of NextEra's UT-Austin testing program is to establish and correlate the degree of ASR progression to overall structural performance, the interim use of the CCI method and the 6-month interval measurements taken, to date, provide reasonable assurance that the level of degradation due to ASR remains essentially the same and that the progression rate is low. As such, the bounding engineering calculations and associated prompt operability determinations remain valid.

Best available information concerning the impact of ASR on a structural member indicates that the formation of ASR gel within the concrete matrix, and subsequent absorption of more water by that gel, results in gel expansion that generates stresses within the concrete matrix. These expansion stresses are both absorbed and transferred between the concrete and reinforcing steel bars, until eventually revealed by the patterned cracking (stress relief) on unrestrained and/or exposed surfaces of the affected structure. For structures that are not triaxially reinforced (as many of the walls at Seabrook Station, having only inner and outer surface horizontal and vertical reinforcements, but no through-wall struts or ties) the potential exist for some undetected out-of-plane crack formation and a potential undetected structural performance impact. As documented in Section 6, the large-scale testing program is intending to provide additional insights to the overall performance of these structural wall designs.

In support of the use of CCI, which is a two-dimensional concrete surface measurement, NextEra is developing plans to install deep pins in ASR-affected walls at Seabrook to better monitor ASR progression. The large scale test specimens fabricated at the UT-Austin facility include three-dimensional through-wall pin placements which will provide a more comprehensive measurement of the ASR expansion and associated impact on structural performance. NextEra hopes to install similar deep pins at the site in order to better correlate the UT-Austin testing results and the two-dimensional CCI data to actual structural performance.

As stated above, within the confines of the reinforcement cage, the ASR expansion is restrained and some of the expansion stresses are transferred to longitudinal strain in the reinforcing bars. As long as, neither the tensile strength of the concrete nor the steel rebar yield strength is compromised (exceed elastic limits), no visible cracking (stress relief) is expected. The amount of restraint imposed by the rebar cage is dependent upon the type, size and design of the rebar used. More heavily reinforced structures resist ASR expansion and may depict a different level of surface cracking compared to a lightly or non-reinforced structure with a similar degree of ASR progression.

9.6 Planned Regulatory Actions

As discussed in Section 6.0 above, and in NextEra's ASR Project CAP, the crediting the FSEL test results for demonstrating current and longer term operability of ASR-affected reinforced concrete structures will be evaluated pursuant to 10CFR50.59 and 10CFR50.90 (license amendment request). The team concluded that this approach appears reasonable and consistent with existing regulatory processes.

The team notes that Combined Crack Indexing (CCI) may become the principle method used by NextEra for monitoring the progression of ASR in affected structures. **However, this method is not recognized by NRC regulatory and design standards, and is not within the current Seabrook licensing basis**. Pending the results of the FSEL testing program, NextEra may propose the use of this methodology for assessing current and future operability of ASR-affected structures.

Comment [A11]: I'm not sure why the method for monitoring would have to be part of the CLB?

9.7 ASR Impact on Containment

As part of NextEra's extent of condition review, evidence of ASR was identified on the exterior surface of containment structure. NextEra initiated a prompt operability determination (No.

1804477) and concluded containment was fully operable and capable of meeting all its design basis functions, with some reduced margin. At the conclusion of this inspection, NextEra had not yet developed a plan for resolving this non-conforming condition. As this issue has been documented in the Seabrook CAP with an open operability determination, resolution of the issue will be monitored via the ROP baseline inspection activities.

10.0 Review of Six-Month Combined Crack Indexing Data

Inspection Scope

The team reviewed the periodic concrete expansion measurements for ASR-impacted Seabrook structures. Specifically, the team examined the supporting documentation for the ASR Crack Index Report dated March 18, 2013 (FP 100811) and the ASR Expansion Measurements Report dated March 18, 2013 (FP100812). The team also conducted interviews and discussions with the responsible NextEra engineering staff. The team used 10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Action," and Criterion XI, "Test Control," as the regulatory guidance to assess the adequacy of NextEra's actions to address ASR-affected reinforced concrete structures.

Findings and Observations

No findings were identified. Overall, the combined crack index (CCI) data show some evidence of continued ASR degradation, but the expansion data (pin to pin measurements) showed no significant changes. There was no change in the CCI data for the containment, but the Electric Tunnel and the Primary Auxiliary Building/Residual Heat Removal (PAB/RHR) vault both show a positive trend in CCI value in the six months since June 2012. While this may be the result of seasonal affects, ASR degradation appears to be ongoing in some Seabrook structures as indicated by some minor incremental crack growth. Collectively, the CCI measurements indicate essentially no structural changes; and therefore no challenges to the conclusions in the current ASR-affected structures' prompt operability determinations. The team noted NextEra's plans to continue the 6-month CCI measurements to establish a stable trend in observable ASR expansion for each uniquely ASR-affected structure. Continued periodic measurements should eliminate the potential influence of seasonal ambient temperature changes from the trend results.

CCI Measurements

In the ASR Crack Index Report (FP100811), NextEra measured CCI values for 26 locations in the monitoring program and compared the results to the data taken in June 2012. The CCI data shows an apparent increase in most (18 of 26) of the monitored locations. NextEra identified that the CCIs measured in December 2012 appears larger than the CCI data measured in June 2012. NextEra concluded the apparent increase in CCI values was due to seasonal temperature variations because the concrete (in December) was significantly colder, which may cause the concrete to contract between the cracks, increasing the apparent crack widths.

The team noted that 3 of 7 monitored locations on the exterior of plant buildings (above grade and more susceptible to seasonal temperature and moisture variations), showed a decrease in

CCI from June to December. Further, 15 of 18 areas showing an increase in crack index were areas monitored on interior buildings surfaces and/or below grade; and therefore less susceptible to seasonal temperature variations. In particular, the Electric Tunnel (areas 3b, 4, and 5) and the PAB/RHR Vault (areas 17, 18, 22, and 23) all show a CCI value increase of between 0.20 to 0.26 mm/m compared to June 2012. These interior, below-grade areas have been chronically wet from ground water infiltration. The team noted there was no change in the CCI values for the Containment Building (Location 14 - Mechanical Penetration MF102-01).

As reported by NextEra, uneven cracking (total crack width in one direction is much larger than in the other direction) and measured larger cracks were identified in the horizontal direction compared to the vertical. The team observed that, over the long term, averaging the horizontal and vertical CCI values may be an adequate representation of overall changes due to ASR of the specific structural member. However, the practice of averaging the horizontal and vertical CCI values is different than outlined by available industry guidance (FHWA-HIF-09-004) that recognizes the influence of reinforcements on crack growth. Thus, reporting an averaged CCI vice directional CCI values separately, could mask the expansion in a preferred direction and hamper the identification of a trend, in the short term. NextEra acknowledged this team observation and initiated a Condition Report (CR 1758920-39) to evaluate this issue.

The team also noted that NextEra revised the method of calculating CCI in the recent 6-month measurement report (December 2012). The CCI measurement reporting method was changed to account for the use of rectangular grids to determine crack index, and thereby normalize index to the total number of lines in the both directions. In so doing, NextEra recalculated the CCI values for the December 2011 and June 2012 data to eliminate potential biasing errors. The team concluded that NextEra's more consistent use of a calculation method would aid the identification of apparent trends.

Structure Expansion Measurements

In the Expansion Measurement Report (FP100812), NextEra performed measurements between pins embedded in the surface of plant buildings at the 26 established CCI monitoring locations. The 26 monitored locations were selected from the 131 locations identified in the ASR Walkdown Report (reference FP100705) which exhibited the highest visible ASR-associated distress. NextEra noted a null result for expansion measurements between pins in most of the 26 monitored locations. Specifically, data recorded in most (436) measurement lines showed no significant changes compared to the baseline data. However, for 5 of the 436 measurement lines, NextEra noted length changes that were unexpected. Further, NextEra noted that the gage points at CCI monitoring locations 1, 9, and 14 had moved out of range of the measurement instrument. NextEra plans to evaluate these locations further.

The team noted that the crack index data shows apparent increase when expansion data in 2-dimensions shows no change. It appears that the CI data better reflects expansion (strain) in the structure compared to the expansion measurements in only 2-dimensions, which may not be a complete indicator of changes in the structure. The team noted that NextEra plans to add deep pins to ASR impacted walls in the monitored locations that will allow expansion measurements in the third direction.

11.0 Review of Adequacy of Revisions to the Phase 3 Walkdown Plans and Schedule

Inspection Scope

During the previous inspection, the team reviewed the overall thoroughness of NextEra's completed and planned ASR walkdown activities conducted in accordance with FP 100642, "ASR Walkdown Scope," Revision 1, and documented in FP 100705, "Seabrook Station: Summary of Alkali Silica Reaction Walkdown Results," Revision 0. At the time of the inspection, not all of the potentially affected structures had been examined and NextEra had drafted a tentative schedule for the completion of the Phase 3 (areas not readily accessible) walkdowns. During this inspection, the team assessed NextEra's final Phase 3 schedule for completeness and to ensure a timely examination of the extent of condition of ASR-affected structures.

Findings and Observations

No findings were identified.

NextEra's ASR extent of condition structures walkdown is being conducted in three phases. Phase 1 involved examination of readily accessible areas of interest; Phase 2 included examination of coated surfaces identified during Phase 1 inspections (coatings had to be removed to expose the concrete surfaces); and Phase 3 examines normally inaccessible structures and areas (e.g. high radiation, manholes, etc.) which have or will be inspected at the earliest opportunity (e.g. routine maintenance or outage activities). Team examination of the Phase 3 walkdown areas identified a minor documentation issue (in addition to the previously documented containment IWL inspection oversight) that the spent fuel pool (SFP) reinforced concrete walls were not included in the planned Phase 3 walkdown. The SFP walls pose a particular challenge to NextEra due to the limited accessibility of the concrete surfaces. At the conclusion of this inspection, NextEra was working to complete their evaluation of various methods to assess the SFP concrete walls. A target date of June 30, 2013 was established to develop the necessary steps to accomplish this task (reference ASR Project Corrective Action Plan, revised April 2013). NextEra had already initiated plans to remove a core sample from the SFP telltale sump, per an earlier commitment made under the license renewal process (reference ____________).

The team assessed the Phase 3 walkdown schedule and concluded the target dates for completion were reasonable. With respect to completing a comprehensive examination of the containment structure, the team concluded that performing this inspection concurrent with the scheduled 2015 refueling outage IWL examination was appropriate and commensurate with the safety significance of the issue. The balance of the Phase 3 extent of condition walkdowns are scheduled for completion in mid-to-late 2013 and during the April 2014 refueling outage. In summary, the team concluded that NextEra's completed and planned extent of condition reviews for identification of ASR-affected reinforced concrete structures was appropriate.

12.0 Aircraft Impact Review

Inspection Scope

The team reviewed NextEra's evaluation of the aircraft impact study performed in response to the identification of ASR. The aircraft impact study for Seabrook containment is described in UFSAR Section 3.8.1.3 and Appendix 2P. As noted in the Updated Final Safety Analysis Report (UFSAR), the postulated aircraft impact load is not combined with any other containment transient design loading. Further, the study assumes the impact area to be on the dome just above the spring line.

Findings and Observations

No findings were identified.

The effects of an aircraft impact were found not to be controlling for overall containment design considerations. Also, the analysis assumes that the enclosure building fails when struck by the aircraft and deforms until the aircraft contacts the containment structure. The containment enclosure building design and analysis is described in UFSAR Section 3.8.4. NextEra's evaluation states that ASR has only been identified in below grade elevations of the containment and containment enclosure buildings, where sufficient moisture has contributed to ASR progression. To date, no above grade (or vicinity of the anticipated aircraft impact area) evidence of ASR has been identified on containment. As discussed in Section 11, a detailed ASR inspection in conjunction with the IWL examination will be conducted in 2015. Accordingly, NextEra has concluded that the Seabrook aircraft impact study remains valid and unaffected, based upon engineering evaluations of other ASR-affected reinforced concrete structures completed, to date.

13.0 UT-Austin Ferguson Structural Engineering Laboratory Visits

Scope of Review

On two separate occasions, members of the team visited the UT-Austin testing facility to observe ongoing activities and inspect general facility quality assurance and control measures as implement per NextEra's regulatory obligations. The team noted that NextEra has contractual agreements with MPR Associates and the UT-Austin Ferguson Structural Engineering Laboratory to oversee and conduct, respectively, the ASR large scale testing program. The team toured the facility, including: main fabrication and testing areas with overhead crane lifting capabilities; outside exposed and protected (green house) specimen curing areas, with continuous or cyclic wetting and drying capability; aggregate and sand storage yard; and office and laboratory spaces for storage and use of calibration and test equipment, as well as, environmentally controlled storage units for a variety of mortar bar, prism, and concrete cylinder test specimens. The team examined the large block anchor bolt test specimens, including the control specimen block which had been tested. The team also witnessed fabrication of the second large shear and lap-splice test beam, and some testing of cylinders for compressive strength and Modulus of Elasticity determination.

Findings and Observations

No findings were identified. The team verified appropriate oversight and quality control practices being implemented. Direct oversight by both UT-Austin supervisory staff and MPR engineers was evident and effective.

14.0 Meetings, Including Exit

On June 27, 2013, the team conducted an exit meeting to discuss the preliminary findings and observations with Mr. Kevin Walsh, Site Vice President, and other members of Seabrook Station staff. The inspectors verified that no proprietary information was retained by the inspectors or documented in this report.

SUPPLEMENTAL INFORMATION

KEY POINTS OF CONTACT

Licensee Personnel
B. Brown, Design Engineering Manager
A. Chesno, Performance Improvement Manager
K. Chew, License Renewal Engineer
R. Cliché, License Renewal Project Manager
M. Collins, Design Engineering Manager
J. Connolly, Site Engineering Director
R. Noble, Project Manager
M. O'Keefe, Licensing Manager
T. Vassallo, Principal Design Engineer
K. Walsh, Site Vice President
P. Willoughby, Licensing Engineer

LIST OF ITEMS OPENED, CLOSED, DISCUSSED, AND UPDATED

Updated
None

Opened
None

Closed
None

LIST OF DOCUMENTS REVIEWED

Procedures
Maintenance Rule Scoping Document, Revision 0
EDS 36180, Structures Monitoring Program, Revision 0, 1, 2

Corrective Action Documents (AR)
1651969, 1629504, 574120, 581434, 1636419, 1673102, 1647722, 1664399, 1677340, 1687932, 1692374, 1698739, 1755727, 1757861, 1819080, 1804477, 1819069

Drawings

Licensing and Design Basis Documents and Calculations
Seabrook Station UFSAR, Revision 14
ACI 318-71
Calculation CD-20
Calculation CD-18
Calculation C-S-1-10168

Miscellaneous Documents
FP 100348, Statistical Analysis-Concrete Compression Test Data (PTL)
FP 100642, Scope for Alkali-Silica Reaction Walkdowns
FP 100641, Procedure for ASR Walkdowns and Assessment Checklist
FP 100661, Compression Testing Concrete Cores (WJE)
FP 100696, Material Properties of ASR-Affected Concrete
FP 100700, Field Investigation
FP 100705, Structure ASR Walkdown Report (MPR 0326-0058-58)
FP 100714, Three Dimensional Dynamic Analysis of Containment Enclosure Building
FP 100715, ASR Impact Study on Containment Enclosure Building
FP 100716, Interim Assessment: Impact of ASR on Structures (MPR-3727)
FP 100717, ACI 318-71 Perspectives
FP 100718, Anchor Test Report (MPR-3722)
FP 100720, Crack Index and Expansion Measurement
FP 100738, Measurements for ASR Crack Indexing on Concrete Structures
FP 100697, MPR 0326-0058-53, White Paper on Structural Implications of ASR: State of the Art, Revision 1
MPR 0326-0058-83, Shear Screening Criteria Used in MPR-3727
FHWA-HIF-09-004, Federal Highway Administration, "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction in Transportation Structures."

Documents Reviewed at FSEL

1. Purchase Order No. 0326 – 0058 -25, dated December 1, 2011 and change order Nos. 1, dated March 21, 2012; No. 2, dated March 27, 2012; No. 3, dated July 23, 2012; and No. 4, August 2, 2012 between MPR Associates Inc. and Ferguson Structural Engineering Laboratory as applied to Anchor Testing Program

2. Contract No. 02293285, dated June 6, 2011, and Amendment Nos. 1, dated October 25, 2011; No. 2, dated December 17, 2011; No. 003, dated January 3, 2012; No. 004, dated February 27, 2012; Amendment 6, dated July 26, 2012, between NextEra and MPR Associates Inc.

3. MPR Letter to Ferguson Structural Engineering Laboratory, dated December 1, 2011, Notice of Intent to Contract for Testing of Anchors in ASR-affected Concreter – authorizing FSEL to develop project-specific quality system manual, implementing procedures for testing and perform initial characterization of the ASR degradation on girders.

4. MPR Letter to Ferguson Structural Engineering Laboratory, dated December 1, 2011, Research on Performance of Anchors in ASR-affected Concrete

5. MPR Letter to Ferguson Structural Engineering Laboratory, dated March 27, 2012, Research on Performance of Anchors in ASR-affected Concrete

6. MPR Letter to Ferguson Structural Engineering Laboratory, dated July 23, 2012, Research on Performance of Anchors in ASR-affected Concrete

7. MPR Letter to Ferguson Structural Engineering Laboratory, dated August 2, 2012, Research on Performance of Anchors in ASR-affected Concrete

8. MPR Letter to Ferguson Structural Engineering Laboratory, dated October 26, 2012, Research on Performance of Anchors in ASR-affected Concrete

9. Purchase Order No. 0326 – 0063 -01, dated June 4, 2012, between MPR Associates Inc. and Ferguson Structural Engineering Laboratory as applied to Beam Testing Program

10. Contract No. 02207204, dated April 27, 2012, NextEra and MPR Associates Inc., related to ASR Concrete Beam Testing Program (for Shear and Lap-splice anchorage)

11. Project Plan 0326 – 0062 -01, Revision 0, dated May 1, 2012, by MPR Associates Inc. as applied to Beam Testing Program

LIST OF ACRONYMS

ACI	American Concrete Institute
ADAMS	Agencywide Documents Access and Management System
AMP	Aging Management Program
AR	Action Request
ASME	American Society of Mechanical Engineers
ASR	Alkali-Silica Reaction
BRE	Building Research Establishment
CAL	Confirmatory Action Letter
CCI	Combined Crack Index
CEB	Containment Enclosure Building
CFR	Code of Federal Regulations
CW	Circulating Water
DCR	Demand to Capacity Ratios
DGB	Diesel Generator Building
DRI	Damage Rating Index
DRP	Division of Reactor Projects
DRS	Division of Reactor Safety
EDG	Emergency Diesel Generator
EFW	Emergency Feedwater
EPRI	Electric Power Research Institute
EOC	Extent-of-Condition
ET	Electric Tunnel
EV	Equipment Valve
FEA	Finite Element Analysis
FHWA	Federal Highway Administration
FP	Foreign Print
FPL	Florida Power and Light
FSEL	Franklin Structural Engineering Laboratory
IMC	Inspection Manual Chapter
IP	[NRC] Inspection Procedure
LF	Load Factor
MPR	MPR Associates, Inc.
NRC	Nuclear Regulatory Commission
PARS	Publicly Available Records
P&ID	Piping and Instrument Diagram
PM	Preventative Maintenance
POD	Prompt Operability Determination
PRA	Probabilistic Risk Assessment
psi	pounds per square inch
QA	Quality Assurance
RCA	Radiologically Controlled Areas
RCE	Root Cause Evaluation
RHR	Residual Heat Removal
SDP	Significance Determination Process
SG&H	Simpson, Gumpertz & Heger

SMP	Structures Monitoring Program
SRI	Senior Resident Inspector
UFSAR	Updated Final Safety Analysis Report
UT-A	University of Texas - Austin
UK	United Kingdom
WO	Work Orders

Lamb, John

From: Barkley, Richard |(b)|
Sent: Monday, July 29, 2013 8:27 AM
To: Lamb, John
Subject: RE: One-Pager to Commission - July 2012

Okay – Thanks!

From: Lamb, John |(b)|
Sent: Monday, July 29, 2013 8:24 AM
To: Barkley, Richard
Subject: RE: One-Pager to Commission - July 2012

Not from my end. The Special Working ASR Team was formed shortly after that one-pager, so I am assuming any further updates were through Rich Conte and Jim Trapp.

From: Barkley, Richard
Sent: Monday, July 29, 2013 8:22 AM
To: Lamb, John; Dentel, Glenn
Subject: FW: One-Pager to Commission - July 2012

Thanks – I gather we haven't sent anything up there since then, correct?

Bill Dean has a meeting with the Chairman next week.

From: Lamb, John
Sent: Monday, July 29, 2013 7:44 AM
To: Barkley, Richard
Subject: One-Pager to Commission - July 2012

Richard,

FYI, attached is a one-pager that went to the Commission.

Thanks.
John

B137

Seabrook - Alkali Silica Reaction in Concrete

June 29, 2012

Goal:

- Continue efforts to complete the technical review of alkali silica reaction (ASR) issues identified at Seabrook and incorporate insights into the ongoing review of the license renewal application.

Status:

- Seabrook continues with detailed testing and evaluations to comprehensively address and manage the issue in the short- and long-term.
- NextEra submitted letters to the NRC on May 3, 10, and 25, 2012. NextEra indicated that they will be taking a number of actions to resolve ASR concerns at Seabrook, including additional short- and long-term testing, revising their operability evaluation, and developing an aging management plan for ASR. The NRC staff issued a confirmatory action letter to NextEra on May 16 to confirm these commitments.
- NextEra completed three CAL commitments on May 25: (1) update the prompt operability determination for the control building, (2) submit the root cause evaluation for the organizational causes of the ASR issue, and (3) submit an evaluation of the impact of ASR on concrete structures and attachments. These items are currently under review by NRC staff.
- On May 31, 2012, the NRC staff sent NextEra a letter to inform the applicant that the review schedule for the Seabrook Station license renewal application was being changed. The last two public milestones (i.e., issuance of final SER and ACRS full committee meeting) have been changed to TBD, because the supplemental information on the actions to applicant plans to manage the aging effects due to ASR was not provided in March 2012 as discussed in a letter to NextEra, dated July 12, 2011, and the supplemental information provided in May 2012 included a significantly new program that warrants additional staff resources to review.
- On June 8, 2012, NextEra completed item 4 of CAL No. 1-2012-002 to submit the corrective action plan for the continued assessment of ASR in concrete structures, including the development of remedial actions to mitigate the effects of ASR.
- On June 21, 2012, NextEra completed item 8 of CAL No. 1-2012-002 to submit the technical details of the testing planned at the contracted research and development facility.
- On June 28, 2012, NextEra reported to Region I the completion of item 5 of CAL No. 1-2012-002 to revise the prompt operability determination for the extent of condition buildings including those building, which have been included in an expanded scope of review based on the site initial assessment. On this same date, NextEra reported the completion of the test per item 6 of CAL No. 1-2012-002, which was a short term aggregate expansion test per ASTM C 1260, Mortar Bar Expansion. The results will be made available to the NRC by July 30, 2012 per the CAL.
- The CAL follow-up inspection began June 18, 2012, and is expected to be completed by August 2012. A public meeting is planned for the fall of 2012, near the site in order to summarize the results to date.

Background/Additional Information:

- ASR is a slow chemical process that can occur over time in hardened concrete and adversely impact the mechanical properties of concrete. The reaction requires reactive aggregate, high alkali content in cement, and adequate moisture to form a gel that expands and results in a network of microcracks.
- In August 2010, during a license renewal assessment, Seabrook reported the presence of ASR degradation of concrete in below-grade walls of several Category 1 structures with groundwater intrusion. Seabrook is the first plant to report ASR degradation in the U.S. nuclear industry. Initial testing of core samples indicated a reduction in compressive strength and elastic modulus properties.
- The NRC's review of this issue to date has determined that there are no immediate safety concerns due, in part, to existing safety margins, the localized nature of the ASR, and ongoing crack monitoring.

Buford, Angela

From: Buford, Angela
Sent: Wednesday, July 31, 2013 3:35 PM
To: Cook, William
Subject: RE: Seabrook Report
Attachments: IR 2012-010 draft 7-31-13 ANGIE COMMENTS.docx

Bill, please find my edits attached. I had to re-do them since I was not able to access my original version (and hopefully I put the comments on the right version) If you want to discuss let me know, and obviously these are just for your consideration.

Thanks,
Angie

From: Cook, William
Sent: Wednesday, July 31, 2013 12:58 PM
To: Buford, Angela
Subject: Seabrook Report

Angie,
Received your voice message. Have everyone's comments, but yours....Michael M. said you were quite busy though. If you can get me your edits by the end of the week, we are in great shape. If your comments aren't too extensive, we can capture them during the report concurrence review. I believe we will have Melanie Galloway concur again for DLR.
Hope all is well.
Regards,
Bill

B138

ENCLOSURE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
2100 RENAISSANCE BOULEVARD, SUITE 100
KING OF PRUSSIA, PENNSYLVANIA 19406-2713

Mr. Kevin Walsh
Site Vice President
Seabrook Nuclear Power Plant
NextEra Energy Seabrook, LLC
c/o Mr. Michael O'Keefe
P.O. Box 300
Seabrook, NH 03874

SUBJECT: SEABROOK STATION, UNIT NO. 1 - CONFIRMATORY ACTION LETTER FOLLOW-UP INSPECTION - NRC INSPECTION REPORT 05000443/2012010

Dear Mr. Walsh:

On June 27, 2013, the U. S. Nuclear Regulatory Commission (NRC) completed a team inspection at Seabrook Station, Unit No. 1. The enclosed inspection report documents the inspection results, which were discussed on June 27, 2013, with you and other members of your staff.

The team inspection examined activities conducted under your license as they relate to safety and compliance with the Commission's rules and regulations and with the conditions of your license. Specifically, the team reviewed selected procedures and records, observed activities, and interviewed station personnel regarding the adequacy of NextEra's actions to address the impact of Alkali-Silica Reaction (ASR) on reinforced concrete structures. The team reviewed selected Confirmatory Action Letter (CAL) 1-2012-002 commitments for adequacy and closure.

Based upon the inspection team (team) on site and in-office reviews, the remaining six CAL items were reviewed and closed, as documented in the enclosed report. The five of the eleven CAL items were previously closed in NRC Inspection Report 05000443/20102009 (NRC Adams ML12338A283).

The NRC determined that the actions committed to in CAL 1-2012-002 have been appropriately satisfied. NextEra has identified and assessed the current operability of ASR-affected structures. The root cause evaluation is complete and identified appropriate corrective actions. Many of the corrective actions are in progress, including an important testing program underway at the University of Texas, Ferguson Structural Engineering Laboratory (FSEL). The resolution of all the corrective actions is necessary to fully resolve the ASR issue. Therefore, while our review of the specific CAL items is complete, the NRC will continue to provide oversight of NextEra's testing being conducted at the FSEL. This testing program is scheduled to occur over the next few years. Additionally, we will continue to assess NextEra's Structural Monitoring Program implementation and assessment of the extent and rate of ASR progression in Seabrook concrete structures. Our decision regarding closure of the CAL will be provided to NextEra in a future correspondence.

Deleted: ASR

It should be noted that the inspection team results are based solely on Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 requirements. The NRC is currently in the process of conducting a separate review of the ASR issue as part of the license renewal process in accordance with 10 CFR Part 54. As such, certain aspects of the ASR issue discussed may also have applicability to the license renewal review and involve additional consideration and require additional information beyond that discussed in this report.

In accordance with 10 CFR 2.390 of the NRCs "Rules of Practice," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of the NRC's document system (ADAMS). ADAMS is accessible from the NRC website at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

Christopher G. Miller, Director
Division of Reactor Safety

Docket No. 50-443
License No: NPF-86

Enclosures:
1. Inspection Report No. 05000443/2012010
   w/ Attachment: Supplemental Information
2. Confirmatory Action Letter 1-2012-002

cc w/encl: Distribution via ListServ

It should be noted that the inspection team results are based solely on Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 requirements. The NRC is currently in the process of conducting a separate review of the ASR issue as part of the license renewal process in accordance with 10 CFR Part 54. As such, certain aspects of the ASR issue discussed may also have applicability to the license renewal review and involve additional consideration and require additional information beyond that discussed in this report.

In accordance with 10 CFR 2.390 of the NRCs "Rules of Practice," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of the NRC's document system (ADAMS). ADAMS is accessible from the NRC website at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

Christopher G. Miller, Director
Division of Reactor Safety

Docket No. 50-443
License No: NPF-86

Enclosures:
1. Inspection Report No. 05000443/2012010
   w/ Attachment: Supplemental Information
2. Confirmatory Action Letter 1-2012-002

cc w/encl: Distribution via ListServ

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NAME	WCook	GDental	JTrapp/	CMiller/
DATE	/ /13	/ /13	/ /13	

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U.S. NUCLEAR REGULATORY COMMISSION

REGION I

Docket No.:	50-443
License No.:	NPF-86
Report No.:	05000443/2012010
Licensee:	NextEra Energy Seabrook, LLC
Facility:	Seabrook Station, Unit No. 1
Location:	Seabrook, New Hampshire 03874
Dates:	November 3, 2012 to April 30, 2013
Inspectors:	W. Cook, Team Leader, Division of Reactor Safety (DRS) S. Chaudhary, Reactor Inspector, DRS W. Raymond, Senior Resident Inspector A. Buford, Structural Engineer, Division of License Renewal (DLR), Office of Nuclear Reactor Regulation (NRR) G. Thomas, Structural Engineer, Division of Engineering, NRR A. Sheikh, Senior Structural Engineer, DLR, NRR N. Floyd, Reactor Inspector, DRS
Approved by:	James Trapp, Chief, Engineering Branch 1 Division of Reactor Safety

SUMMARY OF FINDINGS

IR 05000443/2012010; 11/03/2012 - 06/27/2013; Seabrook Station, Unit No. 1; Confirmatory Action Letter (CAL) Follow-up Inspection Report.

This report covered several weeks of onsite inspection at Seabrook Station, two weeks of inspection at the University of Texas – Austin, and eight months of in-office review by region based inspectors and headquarters reviewers to assess the adequacy of actions taken by NextEra to address the occurrence of Alkali-Silica Reaction (ASR) in reinforced concrete structures at Seabrook Station. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process," Revision 4, dated December 2006.

Cornerstone: Mitigating Systems

During this second CAL follow-up inspection, the team examined the remaining six commitments identified in CAL No. 1-2012-002, dated May 16, 2012. The CAL Items reviewed and closed via this inspection were 2, 4, 7, 8, 9 and 11. In addition, a number of observations documented in the first CAL follow-up inspection (reference Inspection Report 05000443/2012009, Section 9.0) were reviewed and closed in this report. Closure of CAL Item 7 was administrative, in that, NextEra had withdrawn this commitment by letter dated December 13, 2012 (ML12362A323). NextEra's revision to this commitment was approved by the NRC as documented in the CAL revision letter dated January 14, 2013 (ML13014A555). A summary of CAL Item 7 and the remaining CAL items reviewed and closed are documented in the enclosed inspection report.

Although the review and closure of each CAL item signifies the NRC's satisfactory assessment of NextEra's commitments and planned corrective actions to address the non-conforming alkali-silica reaction in Seabrook reinforced concrete structures, the completion of the CAL follow-up inspections and closure of the CAL, itself, is not the completion of NRC review and oversight of NextEra's actions to address the ASR issue. As discussed in the team's review of CAL Item 4 and the revised ICAP submitted on May 1, 2013, NextEra acknowledges that a license amendment request, pursuant to 10CFR50.59, may be submitted to address the change in structural evaluation methodology necessitated by the discovery of ASR and the method elected by NextEra to monitor and provide reasonable assurance of continued operability and functionality of ASR-affected reinforced concrete structures.

The team observed that in 18 of 26 monitored locations the increased combined crack index (CCI) values were small, but greater than measurement uncertainty. Thus, the ASR degradation in the Seabrook structures appears to be active and measurable in some locations. Based upon ASR degradation being a slow process and the Seabrook structures being impacted by ASR in only a small fraction of any structural member, vice uniformly and completely affected, the crack index and expansion measurements to date do not appear to present any appreciable structural changes and therefore no eminent challenges to the conclusions in the current prompt operability determinations. However, the team's observations highlight the need for NextEra to continue the 6-month crack index measurements and trending

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until (i) a stable pattern in the CCI measurement data is evident and the results are reliable and predictable (on a building-specific basis); and, (ii) tests at the UT-Austin FSEL are completed and the results appropriately incorporated into a final operability determination.

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REPORT DETAILS

1.0 Background

Alkali-Silica Reaction (ASR) is a chemical reaction occurring in hardened concrete that can change the physical properties of the concrete and potentially affect structural performance. In June 2009, NextEra identified potential degradation in below-grade concrete structures at Seabrook. In August 2010, NextEra completed petrographic evaluation of concrete core samples, which confirmed ASR as the degradation mechanism. The degraded condition in numerous Seabrook Category I structures was evaluated in the Corrective Action Program via prompt operability determinations (PODs). The PODs were revised as new information became available and improved analytical techniques were incorporated.

NextEra initially used the results of mechanical testing of concrete cores to assess the degree of structural degradation due to ASR. This is a traditional method described in American Concrete Institute (ACI) 228.1R for assessing existing concrete structures. NextEra tested the cores for compressive strength and elastic modulus. NextEra used the methods defined in construction and design code ACI 318-1971 to evaluate the structural capacity (operability) of the ASR-affected buildings. However, the mathematical relationships in ACI-318 are based on empirical data from testing of non-degraded concrete, and these relationships may not hold true for all stages of ASR-affected concrete.

After further review of industry experience and literature pertaining to ASR, NextEra engineering concluded that the core test data was not necessarily indicative of structural performance of ASR-affected reinforced concrete structures. NextEra's engineering evaluation stated that once the cores are removed from the structure, concrete core samples are no longer subject to the strains imposed by the ASR-related expansion or restraints imposed by the steel reinforcing cage. The engineering evaluation also stated that confinement provided by steel reinforcing bars (rebar) and other restraints limit ASR expansion of the concrete within the structure and thereby limit the adverse impact on structural performance. Therefore NextEra engineering concluded that the reduction of mechanical properties observed in mechanical testing of cores was not representative of in-situ concrete performance. Based on this engineering judgment, NextEra stopped taking core samples to evaluate the concrete mechanical properties of structures impacted by ASR and revised the operability assessment approach. NextEra's current approach for assessing structural integrity and operability is to compare available design margins to an assumed reduction in structural capacity due to ASR.

NextEra's operability evaluations were based upon an examination of available design margins and a presumed ASR-caused reduction in structural design capacity for critical limit states. The details of this methodology and related assumptions were developed in NextEra's Interim Assessment (FP 100716). The assessment assumed lower bound values of structural capacity for ASR-affected concrete for limit states based on research test data, primarily from small scale test specimens. The assessment focused on the structural limit states that are the most sensitive to ASR effects (i.e., out-of-plane shear capacity, lap splice development length, and anchorage capacity). The assessment determined the structures were suitable for continued service. A final operability assessment will be conducted by NextEra following evaluation of structural performance based on a proposed large scale testing program of beam specimens representative of Seabrook reinforced concrete structures. The test program has been initiated at the Ferguson Structural Engineering Laboratory at the University of Texas at Austin (UT-A), with some testing (anchors) commenced in 2013 and large beam testing scheduled to be completed in 2015. Based upon the slow progression of the ASR, the current operability evaluations, coupled with the Structures Monitoring Program six-month combined crack indexing, provide reasonable assurance of continued structural operability while the testing program is completed over the next couple of years.

2.0 Confirmatory Action Letter 1-2012-002

Confirmatory Action Letter (CAL) 1-2012-002, dated May 16, 2012, was written to confirm commitments by NextEra (established during a meeting with NRC management and staff on April 23, 2012) with regard to planned actions to evaluate ASR-affected reinforced concrete structures at Seabrook Station. In response to the CAL, NextEra committed to provide information to the NRC staff to assess the adequacy of NextEra's corrective actions to address this significant condition adverse to quality. CAL 1-2012-002 is provided as an Enclosure to this report. The NRC staff also formed a working group to provide appropriate oversight of NextEra's activities to address ASR and to coordinate NRC inspection and review activities. The ASR Working Group Charter (ML121250588) outlines the regulatory framework and general acceptance criterion for NRC oversight and review of this issue. As documented in NRC Inspection Report No. 05000443/2012009, dated December 3, 2012 (ML12338A283) CAL Items 1, 3, 5, 6, and 10 were closed.

Based on the results of this inspection, CAL Items 2, 4, 7, 8, 9, and 11 are closed.

3.0 Review of Alkali-Silica Reaction Root Cause Evaluation (CAL Item 2)

Inspection Scope

As documented in Inspection Report No. 05000443/2012009, the team reviewed NextEra's response to CAL Item 2, "Submit the root cause for the organizational causes associated with the occurrence of ASR at Seabrook Station and related corrective actions by May 25, 2012." The licensee submitted their root cause evaluation (RCE) via letter dated May 24, 2012. Based upon the team's initial review, the inspectors concluded that the second root cause was not sufficiently characterized in NextEra's May 24, 2012, submittal. Specifically, NextEra did not clearly describe the personnel and organizational factors that contributed to inadequacies in the Structures Monitoring Program (SMP). The team discussed this observation with the responsible Seabrook staff and NextEra determined that a revision to the RCE was warranted and revised the RCE to more appropriately develop and characterize this second root cause and the associated corrective actions.

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NextEra submitted a revised RCE summary for NRC review via letter dated May 1, 2013, (ML13151A328, Enclosure 1). The team reviewed the revised RCE summary for clarity and appropriateness of associated corrective actions, consistent with guidance outlined in 10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Action," and NextEra's Corrective Action Program (CAP).

Findings and Observations

The team identified no findings. Based upon the team's review, CAL Item 2 is closed.

As documented in Enclosure 1 to the May 1, 2013 letter, NextEra summarized the two root causes, as follows: RC1 – the ASR developed because the concrete mix design unknowingly utilized a coarse aggregate that would, in the long term, contribute to ASR. Although the testing was conducted in accordance with ASTM standards, those testing standards were subsequently identified as limited in their ability to predict slow reacting aggregate that produced ASR in the long term; and RC2 – based on the long standing organizational belief that ASR was not a credible failure mode due to the concrete mix design, dispositions for Condition Reports involving groundwater intrusion or concrete degradation, along with the structures health monitoring program did not consider the possibility of ASR development. In addition, NextEra identified a contributing cause involving the failure of the organization to prioritize groundwater elimination or mitigation resulting in more concrete area exposed to moisture.

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The team agreed with NextEra's root cause evaluation. The ASTM concrete aggregate testing standards in effect at the time of construction were properly implemented, but later determined to be ineffective in identifying slow reacting, ASR-susceptible aggregates. Those standards were revised by the industry and adopted by NextEra to prevent recurrence. The team also agreed with NextEra's determination that the Structures Monitoring Program did not remain current with concrete industry operating experience and associated failure modes, such as ASR. NextEra's implementation of a broad periodic review process to ensure all systems and component monitoring programs remain current and effective was determined an appropriate corrective action for this causal factor by the team.

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4.0 Integrated Corrective Action Plan (CAL Item 4)

Inspection Scope

CAL No. 1-2012-002 documented NextEra's commitment to submit by June 8, 2012, the corrective action plan (CAL Item 4) for the continued assessment of ASR in concrete structures at Seabrook Station including development of remedial actions to mitigate the effects of ASR, where warranted. By letter dated June 8, 2012 (ML12171A227) NextEra submitted their integrated corrective action plan (CAP) for NRC review. The CAP outlined the major elements of diagnosis, evaluation, prognosis and mitigation of ASR-affected structures as understood at the time. Since June 8, 2012, NextEra has made considerable progress in refining the elements of this plan, implementing the initial phases, and more clearly defining and focusing future actions. Consequently, by letter dated May 1, 2013 (ML13151A328, Enclosure 2) NextEra provided an updated ASR Project CAP.

During this inspection period, the team has had numerous discussions, meetings, and conference calls with NextEra, as well as onsite inspections at both Seabrook Station and UT-Austin to review NextEra's actions to address the ASR-affected reinforced concrete structures. From these interactions, both the team and NextEra have gained greater clarity and understanding of the necessary steps (corrective actions) to address this non-conforming condition impacting safety-related reinforced concrete structures. As previously documented in

Inspection Report No. 05000443/2012009 and detailed in other sections of this report, the team assessed the adequacy of completed and ongoing ASR-related activities identified in the integrated CAP, consistent with guidance outlined in 10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Action," and NextEra's Quality Assurance Program.

Findings and Observations

The team identified no findings. Based upon the team's review, CAL Item 4 is closed. The team understands that NextEra plans to maintain the ASR Project CAP as a "living document" and will update it periodically to capture completion of activities and add new actions, as appropriate.

5.0 Prism Testing Commitment Withdrawn (CAL Item 7)

Inspection Scope

CAL Item 7 committed NextEra to "Complete long term aggregate expansion testing (ASTM C 1293, Concrete Prism Test) by June 30, 2013." The purpose of this CAL item was to determine, in conjunction with the Mortar Bar Testing (CAL Item 6), if the coarse aggregate contributing to ASR in Seabrook reinforced concrete still contained sufficient reactive silica for the alkali-silica reaction to continue long-term under the existing environmental conditions. Alternatively, these tests could demonstrate that the progression of ASR at Seabrook maybe self-limiting due to the depletion of reactive silica in the concrete. The Prism Test (as defined by ASTM C1293) involves monitoring the expansion (by measurement of specimen elongation due to ASR) of the test specimen (a molded concrete brick approximately 3 by 5 by 12 inches in length) over a one year period. Expansion in excess of 0.04% is considered potentially deleterious and a positive test for slow reactive aggregate. The Prism Test is similar to the Mortar Bar Test (reference ASTM C1260), but has a duration of 14 days and an expansion limit of 0.1%.

Based upon the results of the completed Mortar Bar Expansion Testing (reference NRC Inspection Report No. 05000443/2012009, Section 5.0), NextEra concluded that the available quantities of silica in the concrete would not be depleted in the near term and that additional confirmatory testing via the Prism Test method was not warranted. NextEra ran the Mortar Bar Test several weeks beyond the 14-day test (terminated after 103 days) and observed that the alkali-silica reaction was still progressing at the conclusion of the test, indicating the presence of sufficiently reactive aggregate to maintain ASR for a considerably longer period of time. The team noted that the Mortar Bar Test involved the reuse of aggregates from Seabrook test cores (concrete that had already experienced appreciable ASR) and similar aggregate from concrete not affected by ASR. The side-by-side comparison of the test specimens showed no appreciable difference in ASR progression or observed expansion rates. Accordingly, NextEra concluded the Prism Test would add no significant knowledge to the condition assessment of Seabrook concrete. NextEra concluded that all Seabrook reinforced structures are or may be affected by ASR, unless specifically ruled-out by further analysis, such as petrographic examination. By letter dated December 13, 2012, NextEra requested that CAL Item 7 be deleted. By NRC letter dated January 14, 2013 (ML13014A555), the NRC acknowledged and accepted NextEra's technical basis for deleting CAL Item 7 and the CAL was revised, accordingly.

Findings and Observations

No findings were identified. CAL Item 7 is administratively closed.

6.0 Review of Technical Details of Large Specimen Testing Program (CAL Item 8)

Inspection Scope

CAL Item 8 committed NextEra to "Submit the technical details of the testing planned at the contracted research and development facility by June 30, 2012." By letter dated June 21, 2012, (ML12179A281) NextEra submitted the Shear and Lap Splice Testing overview prepared by the Ferguson Structural Engineering Laboratory (FSEL) at the University of Texas at Austin, dated March 15, 2012. The purpose of the test program, as described in the FSEL document, is to provide sufficient data and insights to establish the current and future implications of ASR on Seabrook reinforced concrete structures. Since there is limited available literature or test data relative to the impact of ASR on walls without transverse shear reinforcement (like the majority of Seabrook ASR-affected structures), destructive testing of ASR-affected test specimens will be conducted to evaluate the impact of ASR on out-of-plane shear strength and lap splice development. The test specimens being prepared at FSEL will be of representative scale and design, such that the test results may be correlated to Seabrook structures.

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The team reviewed the June 21, 2012 submittal and conducted a conference call on December 18, 2012, with the NextEra and UT-Austin FSEL staff to better understand the proposed test program. Based upon the complexity of the information discussed and follow-up inspection activities, NextEra prepared a test program overview document and a detailed test specification to supplement the June 21, 2012 CAL response letter. By letter dated May 1, 2013 (ML13151A328 redacted and ML13151A291 un-redacted) NextEra provided the NRC with the "Seabrook Station - Specification for Shear and Reinforcement Anchorage Testing of ASR-Affected Reinforced Concrete," (Enclosures 3 & 4) and "Approach for Shear and Reinforcement Testing of Concrete Affected by Alkali Silica Reaction," (Enclosure 5 & 6). Each of these documents has a proprietary and non-proprietary version.

The team reviewed the revised testing specification and the associated overview document to better understand the overall test program approach and application of test results to resolve the Seabrook ASR-affected concrete non-conforming condition. The team discussed the test program with the FSEL, MPR and responsible NextEra engineering staffs.

Findings and Observations

No findings were identified. Based upon team review of the submitted testing program documents and related inspection activities, the team concluded that NextEra has provided a satisfactory explanation of the proposed large-scale specimen testing program, and CAL Item 8 is closed.

The team concluded that, although NextEra's approach appears reasonable, the use of the testing results to resolve the Seabrook structures' nonconforming condition remains subject to further regulatory review and potential license amendment request, pursuant to 10 CFR 50.59.

The team did not pre-judge the viability of the testing program or associated methodologies for this purpose. The team observed, and NextEra acknowledges, that the CAL Item 8 response documents may be referenced in a future license amendment request, but have only been submitted to satisfy NextEra's commitment to explain the scope and depth of the large-scale specimen testing program.

7.0 Review of Structures Monitoring Program (CAL Item 9)

Inspection Scope

CAL Item 9 committed NextEra to implement an update to the Maintenance Rule (10CFR50.65) Structures Monitoring Program (SMP) to include monitoring requirements for selected locations in areas that exhibit ASR by July 15, 2012. NextEra issued Revision 2 to Structural Engineering Standard 36180, "Structural Monitoring Program," effective July 12, 2012. The primary changes incorporated in Revision 2 to the SMP were: 1) performing periodic (every six months) crack indexing measurements at 26 locations to collect quantitative information on the progression of ASR expansion/degradation; 2) establishing crack width (1.0 mm or greater) and Combined Crack Index (1.0 mm/m or greater) thresholds for conducting structural evaluations (reference Foreign Print 100716, Seabrook Station: Impact of ASR on Concrete Structures and Attachments); and 3) the addition of Federal Highway Administration (FHWA) document FHWA-HIF-09-004, "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction in Transportation Structures," dated January 2010, as a reference.

The team reviewed the adequacy of these changes to the SMP to monitor ASR in Seabrook reinforced concrete structures. While not endorsed by the NRC or committed to by NextEra in Seabrook's licensing basis, the team used the American Concrete Institute (ACI) Committee Report 349.3R-96, "Evaluation of Existing Nuclear Safety-Related Concrete Structures," as a reference to assess the adequacy of the revisions made to the SMP for monitoring the progression of ASR.

Based partially on NRC observations, NextEra issued Revision 3 to the SMP on April 30, 2013. The principle changes in Revision 3 of the SMP are: 1) the addition of periodic (every 30 months) combined crack indexing (CCI) measurements at 72 discrete locations identified as Tier II (Acceptable with Deficiency) areas (CCI values between 0.5 mm/m and 1.0 mm/m, or crack widths greater than 0.2 mm, but less than 1.0 mm) to collect quantitative information on the progression of ASR expansion/degradation; and, 2) inclusion of the periodic ground water sampling program for monitoring of chemical attributes detrimental to concrete structures. During follow-up discussion with the NextEra staff, the team learned that NextEra is considering two additional SMP revisions, dependent upon the results of the large specimen test program and further engineering evaluation. These potential revisions involve additional core sampling for periodic petrographic examination and correlation to the test program data, and installation of deep pins for monitoring of expansion in the out-of-plane direction (reference NextEra's May 1, 2013, Response to Confirmatory Action Letter (ML13151A328) Enclosure 2, ASR Project Corrective Action Plan).

Findings and Observations

The team identified no findings in this area. CAL Item 9 is closed.

The team noted that changes made to the SMP to address ASR were generally consistent with the evaluation and monitoring methods outlined in ACI 349.3R-96. The team confirmed that NextEra had incorporated a three-tiered visual inspection criteria, as outlined in Sections 5.1 through 5.3 of ACI 349.3R-96. NextEra has also augmented this visual inspection criteria with periodic (six-month and 30-month interval) CCI measurements and associated structural evaluation thresholds based upon direct measurement (CCI) results. The CCI monitoring, performed at 98 selected locations (including containment) was implemented by NextEra based upon this method being a readily measurable indicator of ASR related progression and based, in part, upon endorsement by FHWA and outlined in FHWA-HIF-09-004.

The team understands that crack growth monitoring provides a visual indication of the progression of ASR within a reinforced concrete structure. The relative width and number of visible cracks may be correlated to the overall progression of ASR and may be used to evaluate ASR impact on structural performance. However, ASR cracking and crack propagation is closely associated with the specific reinforcement design and structural loading. Accordingly, the adequacy of CCI measurement as a long term structures monitoring methodology for Seabrook structures is being further evaluated by NextEra via the UT-Austin FSEL testing program. Based upon discussions with the responsible NextEra engineering, MPR and UT-Austin staffs, the results of the UT-Austin testing program is intended to be used to validate this methodology for the specific application at Seabrook, as appropriate.

Evaluation of infiltration water chemistry and groundwater monitoring: ACI 349.3R-96 discusses environmental monitoring and related effects of aggressive water chemistry, including the potential for leaching. Accordingly, NextEra has integrated the periodic monitoring of ground water chemistry into the SMP (reference Revision 3, dated 4/30/2013, Attachment 4). Based upon follow-up discussions with the NextEra staff, the team understands that NextEra plans to expand the water chemistry monitoring program (reference AR No. 1758920-40) to include periodic analysis of infiltrated water (water that has migrated through below grade reinforced concrete walls). The team acknowledges the absence of specific standards for collection and analysis of infiltrated water samples. However, the establishment of an initial baseline analysis and continued periodic monitoring should provide some relative trend data for further evaluation and follow-up actions, as appropriate.

The team concluded that the implemented and planned SMP enhancements should provide NextEra with an improved program to assess the extent and degree of ASR progression and to more thoroughly monitor the environmental factors contributing to ASR. From a performance-based perspective, NextEra's initial SMP revision (Revision 2) was adequate. The SMP Revision 3 enhancements are more inclusive of the multiple activities NextEra has implemented to monitor and assess ASR impact on reinforced concrete structures and is better aligned with ACI 349.3R guidance.

8.0 Review of Anchor Testing Program (CAL Item 11)

Inspection Scope

The micro-cracking caused by ASR may adversely impact the structural capacity of anchors that support safety-related piping, cable trays and other components. NextEra's initial operability determinations were supported by anchor performance testing conducted on readily available ASR-degraded specimens previously fabricated at or obtained by FSEL, UT-Austin (reference FP 100718). As documented in inspection report No. 05000443/2012009, the initial testing demonstrated satisfactory performance of the anchors in ASR-affected concrete during the earlier stages of ASR progression. NextEra's evaluation also illustrated that the eventual reduction in capacity due to ASR was sufficiently offset by established anchor manufacturer's design margins (FP 100716). However, based upon the limitations of the testing performed (on ASR-affected test specimens of different composition and compressive strength than Seabrook reinforced concrete structures) NextEra planned to conduct further testing. The planned testing involves anchors installed (both during specimen fabrication and post-fabrication) in ASR-affected test specimens that more closely replicate the reinforced concrete structures and anchor configurations at Seabrook.

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By licensee letter dated December 13, 2012, (ML12362A323) NextEra requested a revision to CAL Item 11 to address a schedule challenge to the targeted anchor testing program completion date. NextEra also proposed redefining CAL Item 11 to be consistent with the wording of CAL Item 8, regarding large-scale specimen testing. Specifically, NextEra revised their commitment to read, "Submit technical details of the anchor test program planned at the contracted research and development facility by February 28, 2013." The original commitment read, "Complete anchor test program by December 31, 2012. Results will be available for NRC review approximately 30 days after testing is complete." Based upon unforeseeable specimen fabrication delays and the slow progression of accelerated ASR aging, NextEra identified that it would not be possible to complete the anchor testing per the original commitment date. The NRC accepted NextEra's revised commitment, as documented in NRC letter dated January 14, 2013 (ML13014A555).

The team reviewed the details and adequacy of NextEra's anchor testing program as outlined in the proprietary "Anchor Testing Program Overview," dated February 26, 2013. The anchor testing program overview and associated testing specifications were docketed for NRC review via NextEra letter dated February 28, 2013 (ML13088A218 redacted and ML13088A229 un-redacted, dated March 15, 2013). The technical overview document and accompanying specifications outline the major elements of the proposed anchor testing program, including the key attributes of the fabrication of the test specimens, monitoring of the specimens as accelerated ASR aging progresses, and the details of the testing of individual anchor bolt configurations.

Findings and Observations

The team identified no findings. Based upon the team's review, CAL Item 11 is closed.

During the team's visits to the UT-Austin FSEL, the team observed the conditions and controls implemented for the aging of the test blocks and testing of concrete sample cylinders for compressive strength and Modulus of Elasticity. The team witnessed appropriate implementation of the testing procedures by the FSEL students and faculty and proper oversight of these activities by the MPR responsible engineering and quality assurance staff.

At the conclusion of the inspection, NextEra had not achieved the desired ASR progression of the test blocks to conduct the first round of ASR-affected anchor testing. However, the team did review the results of the control specimen anchor testing completed in November 2012. The purpose of the control specimen testing was to establish a baseline to judge the potential reduction in anchor bolt capacity due to ASR. Review of the test data (reference MPR Memorandum DRN 0326-0058-163, dated June 18, 2013) identified that all anchor bolts test results were in agreement with calculated capacities and an appropriate baseline had been established for future testing.

9.0 Review of Previously Identified Issues of Interest

9.1 Structural Evaluations for 13 Locations

As documented in Inspection Report 05000443/2012009, NextEra identified 26 locations (including containment) as having patterned cracking with a CCI of greater than 1.0 mm/m. Per the SMP, Revision 2, structures with a CCI of >1.0 mm/m require a structural evaluation. NextEra's Interim Assessment documented an engineering judgment that biased the performance of detailed structural evaluations to the 11 locations with a CCI > 1.5 mm/m. The locations with a CCI of between 1.0 and 1.5 mm/m (13 locations) were considered bounded by the 11 areas subjected to a detailed evaluation. The lack of a documented structural evaluation for the 13 locations with a CCI of between 1.0 and 1.5 mm/m was a minor performance deficiency which NextEra entered into the Corrective Action Program (AR 1804477 and AR 1819080). During this inspection, the team reviewed Calculation C-S-10168, Revision 1 , and FP 100716, "Seabrook Station: Impact of Alkali-Silica Reaction on Concrete Structures and Attachments," Revision 2, which incorporated the additional evaluations for the 13 locations.

The evaluation methodology included reviewing the calculation that governs the design of the structures to determine the design parameters associated with the general area of ASR degradation. The structural member's load demand and capacity were then noted and the margin calculated for comparison against the potential reductions in load capacities caused by ASR. The assumed reductions in capacity were determined based on lower bound values established in industry literature. A summary of the evaluation results was provided in Table 3 of FP100716, Revision 2. For areas where design margins were insufficient to offset assumed reductions, further review was performed to recapture margin. Specifically, for two areas (Electric Tunnel and Discharge Structure), the design calculation used conservative load factors which were lowered to establish more representative demand loads, as described in Calculation C-S-1-10168, Revision 1. NextEra demonstrated additional margin to assure structural integrity despite the assumed reduction in capacity due to ASR. However, in the calculation for Electric Tunnel area MF101 (C-S-1-10168, pg 30), NextEra reduced the hydrostatic load factor (1.4) to achieve a more realistic load demand. NextEra plans to credit the 1.4 load factor in the load demand calculation to establish full qualification per the FSAR licensing basis in the final operability determination, following completion of the testing program at UT-Austin.

The team concluded that NextEra's initial approach to perform a bounding analysis for areas with CI >1.5 mm/m was not conservative, because the design margins vary in each structural member of each reinforced concrete structure. This conclusion highlights the need, once the impact of the ASR degradation on structural capacities is determined from the UT-Austin FSEL test program, for NextEra to closely review the design calculations for each ASR impacted area to assure margins remain acceptable without having to remove or reduce the load factors assumed in the current licensing basis.

Comment [BA1]: Possibly consider mentioning resolution of this issue through license amendment request? It seems we are leaving it open, when we do intend for there to be NRC involvement in the resolution of these structural evaluations.

9.2 Review of Core Sample Material Property Testing

As documented in IR No. 05000443/2012009, Section 3.2.9, the NRC planned to reexamine the need of additional core sampling of Seabrook structures for the purpose of monitoring and assessing the condition of ASR-affected reinforced concrete. For the long term, NextEra has elected to evaluate structural performance (operability) of the Seabrook ASR-affected reinforced concrete structures via a testing program involving large specimens that are fabricated to closely replicate the Seabrook concrete and reinforcement design. NextEra has pursued this method, vice detailed material properties testing of core samples, based upon available laboratory testing and data that indicates that measurable material properties of removed cores do not, under all circumstances, accurately represent the "in situ" mechanical properties of the concrete, that prior to removal, was subjected to the associated structural compressive stresses (dead loads, live loads, and hydrostatic loads) and inherent restraint due to reinforcement bars. In addition, as identified in the associated core sampling standard (ASTM C42, "Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete") core sample test results may be "…affected by many factors such as the strength level of the concrete, the in-place temperature and moisture histories, the degree of consolidation, batch-to-batch variability, the strength-gain characteristics of the concrete, the condition of the coring apparatus, and the care used in removing cores."

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Team review of this issue has identified two general approaches to gaining an informed understanding of the impact of ASR on reinforced concrete structures. One approach is that being taken by NextEra to assess the overall structural performance of an ASR-affected structural member, much like (but not the same) as the performance of a load test prescribed by ACI 318, "Building Code Requirements for Structural Concrete," Chapter 20, "Strength Evaluation of Existing Structures." Whereas, the alternative approach involves analytical evaluations using as an input the measureable steel and concrete material property values derived from samples, also recognized by ACI 318, Chapter 20. In both approaches, the validity of the results is dependent upon the accuracy/representativeness of measurable inputs/outputs. Concerning NextEra's chosen approach, in addition to fabrication of representative large scale test specimens, NextEra is challenged to appropriately correlate the test program results to the Seabrook structures. Accordingly, the team understands that NextEra plans to take additional core samples from both the test specimens and the Seabrook structures to better correlate the concrete ASR-affects via petrography and mechanical testing. As outlined in NextEra's April 2013 revision to the ASR Project CAP, future revisions to the SMP may involve the use of core sampling to validate CCI correlations via petrographic examination.

9.3 Containment Prompt Operability Determination (POD) and Pre-stressing Effects of ASR

As previously discussed in the NRC Inspection Report No. 05000443/2012009, the team noted that the confinement provided by the steel reinforcement bar (rebar) cage restrains ASR expansion resulting in ASR-induced or "chemical" pre-stressing of affected structural members. The team observed that NextEra had provided a qualitative explanation of this condition in the Interim Assessment (FP 100716), and in the containment structural evaluation and prompt operability determination POD (AR 1804477). The team concluded in IR No. 05000443/2012009 that a quantitative evaluation of this condition may be warranted to address this aspect of the non-conforming ASR condition.

During this inspection, the team discussed the impact of ASR-induced pre-stressing on reinforced concrete structures with NextEra and reviewed NextEra's assessment in AR/POD 1804477. In simple terms, the effect of this "chemical" pre-stressing is to both increase the compressive stresses in the concrete (within the rebar cage) and to increase the tensile stresses in the rebar, as long as the rebar cage restraint is sustained (i.e., the concrete remains anchored to the rebar.) Similar to fabricated pre-stressed concrete structural members, the ultimate load carrying capacity of the reinforced member is not significantly changed by the ASR-induced pre-stress, but the tensile stress in the reinforcing steel caused by the concrete expansion results in a corresponding compressive stress on the concrete that balances the added load, and initially results in reduced deflections and stiffer structural behavior. However, without the ability to quantify the effect and account for the chemical prestressing in engineering evaluations, the team concluded that while the ASR-induced pre-stressing may result in some minor beneficial effects in terms of structural stiffness, this cannot and should not be credited for the purpose of structural evaluation. It is a possibility that ASR conditions could result in the steel reinforcement strain limits being exceeded that could compromise the overall structural performance. However, the team acknowledged that for there to be a concern for structural integrity, more advanced ASR conditions would likely be identified by obvious visible indications of severe concrete surface cracking and would be addressed before there is a threat to structural performance of ASR-affected structures.

The team noted that NextEra had not quantified the ASR induced stresses in the concrete reinforcement. The team noted further that although the crack index had been measured at three containment areas impacted by ASR and absent quantitative analyses, NextEra was unable to show the containment reinforcement was below yield. Further, the team noted that the current design code for containment does not allow containment reinforcement strains to be above yield. The Seabrook containment is designed to ASME III, 1971, and used allowable stress design methodology. This methodology does not allow for stresses to exceed the elastic limit.

> "In order to keep the containment basically elastic under service load conditions and below the range of general yield under factored primary loads, the allowable stresses and strains in this subsection shall not be exceeded."

[Note: Seabrook design basis is ASME III,1971; determine what the 1971 edition said]

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The team noted based on measured crack index data that it is possible for strains in containment reinforcement to be above yield. However, this condition is not certain absent a definitive correlation between the containment crack index and stress/strain in the rebar. This matter was discussed with NextEra representatives who stated actions would be taken to determine the effects of ASR relative to the containment design code requirements.

The team concluded that was no significant safety concern because: (1) the containment is heavily reinforced and ASR is highly localized affecting a small percentage of containment area; (2) the concrete stain (crack index) measured at the surface might not reflect the condition of the reinforcement; (3) the expansion noted at the containment location with highest crack index (mechanical penetration room, 270 degree azimuth) may be surface shrinkage and not ASR; and, (4) the integrated leak rate test in 2010 showed the containment returning to preexisting conditions. See Section 9.6 of this report, "Planned Regulatory Actions," which describes NextEra's plans to address the containment non-conforming condition within the corrective action program.

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9.4 Assessment of the Need for Further Rebar Examinations

As previously documented in IR No. 05000443/2012009, Section 3.2.9, the NRC reviewed the potential for ASR having an adverse impact on rebar. NextEra and their engineering consultants had concluded that rebar is unaffected by ASR-degraded concrete unless the cover concrete is severely damaged and the rebar is exposed. Ample alkali remains in the concrete to maintain rebar passivity to preclude a corrosive environment.

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After further review, the team finds the licensee's position acceptable. Based upon the examination of Seabrook rebar to date, although limited, and review of available industry operating experience associated with reinforced concrete degradation mechanism, the team concluded that ASR does not currently pose any significant threat to the integrity of the reinforcing steel bars at Seabrook. In accordance with the Seabrook SMP and their referenced American Concrete Institute 349.3R-96, "Evaluation of Existing Nuclear Safety Related Concrete Structures," periodic visual inspections (signs of leaching, staining, spalling and popouts) coupled with soil and groundwater testing for aggressive chemistry conditions (chlorides, sulfates and pH) provide appropriate monitoring and industry recommended detection methodology. Consequently, the team has concluded that no additional rebar examinations (removing the cover concrete to expose rebar for visual inspection) are currently necessary.

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9.5 Use of Combined Crack Indexing for Structures Monitoring Program

As previously documented in IR No. 05000443/2012009, Section 6.0, the team planned to examine NextEra's basis for using Combined Crack Indexing (CCI) as the primary SMP method to monitor the progression of ASR in Seabrook structures. The team understands that the basis for NextEra's selection of CCI for monitoring, as endorsed by the FHWA, is that CCI provides a direct visual and measurable method for the detection and monitoring of ASR progression. Although the objective of NextEra's UT-Austin testing program is to establish and correlate the degree of ASR progression to overall structural performance, the interim use of the CCI method and the 6-month interval measurements taken, to date, provide reasonable assurance that the level of degradation due to ASR remains essentially the same and that the progression rate is low. As such, the bounding engineering calculations and associated prompt operability determinations remain valid for the near term.

Based upon detailed review and related inspection activities, the team gained a better understanding of the development and progression of ASR during this inspection. The formation of ASR gel within the concrete matrix, subsequent absorption of more water by that gel, and the resultant gel expansion generate stresses within the concrete matrix. These expansion stresses are transferred to the concrete and relieved by cracking that is present in both the exterior cover concrete and inside the rebar cage. For structures that are not triaxially reinforced (which includes the majority of the walls at Seabrook Station, and no through-wall shear reinforcement) the potential exists for some undetected out of plane cracking and which could result in an undetected impact on structural performance. As documented in Section 6, the large-scale testing program is targeted to provide insights to the overall performance of non triaxially reinforced wall structures.

UT-Austin test specimens clearly illustrate that unrestrained, the ASR gel expansion leads to visible cracking (stress relief) with typical concentration of that stress relief along a single large crack line. In contrast, within the confines of the reinforcement cage, the ASR expansion is restrained and the expansion stresses are transferred to the reinforcing bars. The added stresses strain are carried by the steel rebar until its strength is reached. As a result, within a reinforced concrete structure, the visible ASR patterned cracking will be smaller and finer, since the rebar is carrying the load and providing restraint to the concrete. The amount of restraint provided by the rebar is dependent upon the type, size and design of the concrete section. More heavily reinforced structures would more readily resist ASR expansion and may depict a different level of CCI compared to a lightly or non-reinforced structure with a similar degree of ASR progression.

Accordingly, the team views the use of CCI in NextEra's SMP as an appropriate interim monitoring method. The team understands, pending satisfactory testing program results, that NextEra may subject the testing program and associated test results to a 10CFR 50.59 review prior to formally crediting the program and results for long-term structural operability. This potential course of events may lead to NRC staff review of a license amendment request and accordingly, be available for public review and comment.

Bayrack to provide an addendum to the "mothership" document.

9.6 Planned Regulatory Actions

Under Section 4.0 of the ASR Project CAP, NextEra acknowledged the likelihood of a license amendment request, pursuant to 10CFR50.59 and 10CFR50.90, to credit the test results for demonstrating current and longer term operability and structural performance with ASR-affected concrete. The team observed that this approach appears reasonable and consistent with existing regulatory processes, but did not pre-judge the viability of the methodology or outcome.

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Comment [BA2]: Stress ~ Strain. Stress doesn't get transferred into strains, it is essentially the same thing except that strain is a unitless measure of stress that relates it to deflection of the member. It's misleading to write that stresses turn into strains or to interchangeably use the terms if we're not intending to

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As part of NextEra's extent of condition review, evidence of ASR was identified on the exterior surface of containment structure. NextEra initiated a prompt operability determination (No. 1804477) and concluded containment was fully operable and capable of meeting all its design basis functions, with some reduced margin. At the conclusion of this inspection, NextEra had not yet developed a plan for resolving this non-conforming condition. As this issue has been documented in the Seabrook CAP with an open operability determination, resolution of the issue will be monitored via the ROP baseline inspection activities.

Comment [BA3]: Does this jive with the previous statement that the containment may not be meeting its required design basis, considering it is required to maintain rebar stresses in the elastic range and the licensee cannot show that. Is it worth a sentence here? Or is it at all conflicting with the previous discussion?

The team understands that Combined Crack Indexing (CCI) may become the principle method used by NextEra for monitoring the progression of ASR in affected structures. However, this method is not recognized by NRC regulatory and design standards or within the current Seabrook licensing basis. Pending the results of the UT-Austin FSEL testing program, NextEra may include in a license amendment the proposed use of this methodology for assessing current and future operability of ASR-affected structures.

In support of the use of CCI, which is a two-dimensional concrete surface measurement, NextEra is developing plans to install deep pins in ASR-affected walls at Seabrook to better monitor ASR progression. The large scale test specimens fabricated at the UT-Austin facility include three-dimensional through-wall pin placements which will provide a more comprehensive measurement of the ASR expansion and associated impact on structural performance. NextEra hopes to install similar deep pins at the site in order to better correlate the UT-Austin testing results and the two-dimensional CCI data to actual structural performance.

10.0 Review of Six-Month Combined Crack Indexing Data

Inspection Scope

The team reviewed the periodic concrete expansion measurements for ASR-impacted Seabrook structures. Specifically, the team examined the supporting documentation for the ASR Crack Index Report dated 3/18/13 (FP 100811) and the ASR Expansion Measurements Report dated 3/18/13 (FP100812). The team also conducted interviews and discussions with the responsible NextEra engineering staff. The team used 10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Action," and Criterion XI, "Test Control," as the regulatory guidance to assess the adequacy of NextEra's actions to address ASR-affected reinforced concrete structures.

Findings and Observations

No findings were identified. Overall, the combined crack index (CCI) data show some evidence of continued ASR degradation, but the expansion data (pin to pin measurements) showed no significant changes. There was no change in the CCI data for the containment, but the "B" Electric Tunnel and the Primary Auxiliary Building/Residual Heat Removal (PAB/RHR) vault both show a positive trend in CCI value in the six months since June 2012. Thus, ASR degradation appears to be ongoing in some Seabrook structures as indicated by some minor incremental crack growth. Collectively, the CCI measurements indicate essentially no structural changes; and therefore no challenges to the conclusions in the current ASR-affected structures' prompt operability determinations. The team endorses NextEra's plans to continue the 6-month CCI measurements compared to its structures monitoring program-established acceptance criteria to determine a stable trend in observable ASR expansion for each uniquely ASR-affected structure. Continued periodic measurements should eventually eliminate the potential influence of seasonal ambient temperature changes from the trend results.

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CCI Measurements

In the ASR Crack Index Report (FP100811), NextEra measured CCI values for 26 locations in the monitoring program and compared the results to the data taken in June 2012. The CCI data shows an apparent increase in most (18 of 26) of the monitored locations. NextEra identified that the CCIs measured in December 2012 appears larger than the CCI data measured in June 2012. NextEra concluded the apparent increase in CCI values was due to seasonal temperature variations because the concrete (in December) was significantly colder, which may cause the concrete to contract between the cracks, increasing the apparent crack widths.

The team noted that 3 of 7 monitored locations on the exterior of plant buildings (above grade and more susceptible to seasonal temperature and moisture variations), showed a decrease in CCI from June to December. Further, 15 of 18 areas showing an increase in crack index were areas monitored on interior buildings surfaces and/or below grade; and therefore less susceptible to seasonal temperature variations. In particular, the Electric Tunnel (areas 3b, 4, and 5) and the PAB/RHR Vault (areas 17, 18, 22, and 23) all show a CCI value increase of between 0.20 to 0.26 mm/m compared to June 2012. These interior, below-grade areas have been chronically wet from ground water infiltration. The team noted there was no change in the CCI values for the Containment Building (Location 14 - Mechanical Penetration MF102-01).

As reported by NextEra, uneven cracking (total crack width in one direction is much larger than in the other direction) and measured larger cracks were identified in the horizontal direction compared to the vertical. The team observed that, over the long term, averaging the horizontal and vertical CCI values may be an adequate representation of overall changes due to ASR of the specific structural member. However, the practice of averaging the horizontal and vertical CCI values is different than outlined by available industry guidance (FHWA-HIF-09-004) that recognizes the influence of reinforcements on crack growth. Thus, reporting an averaged CCI vice directional CCI values separately, could mask the expansion in a preferred direction and hamper the identification of a trend, in the short term. NextEra acknowledged this team observation and initiated a Condition Report (CR) to evaluate this issue (need CR #).

The team also noted that NextEra revised the method of calculating CCI in the recent 6-month measurement report (December 2012). The CCI measurement reporting method was changed to account for the use of rectangular grids to determine crack index, and thereby normalize index to the total number of lines in the both directions. In so doing, NextEra recalculated the CCI values for the December 2011 and June 2012 data to eliminate potential biasing errors. The team concluded that NextEra's more consistent use of a calculation method would aid the identification of apparent trends.

Structure Expansion Measurements

In the Expansion Measurement Report (FP100812), NextEra performed measurements between pins embedded in the surface of plant buildings at the 26 established CCI monitoring locations. The 26 monitored locations were selected from the 131 locations identified in the ASR Walkdown Report (reference FP100705) which exhibited the highest visible ASR-associated distress. NextEra noted a null result for expansion measurements between pins in most of the 26 monitored locations. Specifically, data recorded in most (436) measurement lines showed no significant changes compared to the baseline data. However, for 5 of the 436 measurement lines, NextEra noted length changes that were unexpected. Further, NextEra noted that the gage points at CCI monitoring locations 1, 9, and 14 had moved out of range of the measurement instrument. NextEra plans to evaluate these locations further.

The team noted that the crack index data in horizontal and vertical directions shows apparent increase when expansion data in 2-dimensions shows no change. It appears that the CI data better reflects expansion in the structure compared to the expansion measurements in only 2-dimensions, which may not be a complete indicator of changes in the structure. The team noted that NextEra plans to add deep pins to ASR impacted walls in the monitored locations that will allow expansion measurements in the out of plane direction.

Comment [BA4]: If this isn't right, change it. I was just not certain as to what this was referring to

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11.0 Review of Adequacy of Revisions to the Phase 3 Walkdown Plans and Schedule

Inspection Scope

During the previous inspection, the team reviewed the overall thoroughness of NextEra's completed and planned ASR walkdown activities conducted in accordance with FP 100642, "ASR Walkdown Scope," Revision 1, and documented in FP 100705, "Seabrook Station: Summary of Alkali Silica Reaction Walkdown Results," Revision 0. At the time of the inspection, not all of the potentially affected structures had been examined and NextEra had drafted a tentative schedule for the completion of the Phase 3 (areas not readily accessible) walkdowns. During this inspection, the team challenged NextEra's final Phase 3 schedule for completeness and to ensure a timely examination of the extent of condition of ASR-affected structures.

Findings and Observations

No findings were identified.

NextEra's walkdown was being conducted in three phases. Phase 1 involved examination of readily accessible areas of interest; Phase 2 included examination of coated surfaces identified during Phase 1 inspections (coatings had to be removed to expose the concrete surfaces); and Phase 3 examines normally inaccessible structures and areas (e.g. high radiation, manholes, etc.) which have or will be inspected as the opportunity presents itself (e.g. routine maintenance or outage activities). Team examination of the Phase 3 walkdown areas identified (in addition to the previously documented containment IWL inspection oversight) that the spent fuel pool (SFP) reinforced concrete walls were omitted from the planned Phase 3 walkdown. The SFP walls pose a particular challenge to NextEra due to the limited accessibility of the concrete surfaces. At the conclusion of this inspection, NextEra was working to complete their evaluation of various methods to assess the SFP concrete walls. A target date of June 30, 2013 was established to firm-up the necessary steps to accomplish this task (reference ASR Project Corrective Action Plan, revised April 2013). NextEra plans to remove a core sample from the SFP telltale sump, per an earlier commitment made under the license renewal process (reference ____________).

Comment [BA5]: I can/will find this out

The team also assessed the timing of the walkdowns for the balance of the areas included in the Phase 3 schedule and concluded the target dates for completion of these walkdowns were reasonable. As evidenced by the observed slow progression of ASR and impacted areas evaluated, to date, no immediate safety concerns arise from ASR-affected reinforced concrete structures. With respect to completing a comprehensive examination of the containment structure, the team agrees with NextEra's determination to complete that inspection concurrent with the scheduled IWL examination scheduled for the 2015 refueling outage. The balance of the Phase 3 structures walkdowns are scheduled for completion in mid-to-late 2013 and the April 2014 refueling outage. In summary, the team concluded that NextEra's completed and planned extent of condition reviews for identification of ASR-affected reinforced concrete structures is appropriate.

12.0 Aircraft Impact Review

Inspection Scope

The team reviewed the NextEra's recent evaluation of the aircraft impact study performed in response to the identification of ASR. The aircraft impact study for Seabrook containment is described in UFSAR Section 3.8.1.3 and Appendix 2P. As noted in the UFSAR, the postulated aircraft impact load is not combined with any other containment transient design loading. Further, the study assumes the impact area to be on the dome just above the spring line.

Findings and Observations

No findings were identified.

The effects of an aircraft impact were found not to be controlling for overall containment design considerations. Also, the analysis assumes that the enclosure building fails when struck by the aircraft and deforms until the aircraft contacts the containment structure. The containment enclosure building design and analysis is described in UFSAR Section 3.8.4. NextEra's evaluation states that ASR has only been identified in below grade elevations of the containment and containment enclosure buildings, where sufficient moisture has contributed to ASR progression. Above grade and in the vicinity of the anticipated aircraft impact area, there is no detrimental ASR affect. Accordingly, NextEra concluded that the Seabrook aircraft impact study remains valid and unaffected by the identification of ASR-affected reinforced concrete structures.

13.0 UT-Austin Ferguson Structural Engineering Laboratory Visits

Scope of Review

On two separate occasions, members of the team visited the UT-Austin testing facility to observe ongoing activities and inspect general facility quality assurance and control measures as implement per NextEra's regulatory obligations. The team understands that NextEra has contractual agreements with MPR Associates and the UT-Austin Ferguson Structural Engineering Laboratory to oversee and conduct, respectively, the ASR large scale testing program. The team toured the facility, including: main fabrication and testing areas with overhead crane lifting capabilities; outside exposed and protected (green house) specimen curing areas with continuous or cyclic wetting and drying capability; aggregate and sand storage yard; and office and laboratory spaces for storage and use of calibration and test equipment, as well as, environmentally controlled storage units for a variety of mortar bar, prism, and concrete cylinder test specimens. The team examined the large block anchor bolt test specimens, including the control specimen block which had been tested. The team also witnessed fabrication of the second large shear and lap-splice test beam, and some testing of cylinders for compressive strength and Modulus of Elasticity determination.

Deleted: ,

Findings and Observations

No findings were identified. The team observed overall excellent oversight and quality control practices being implemented. Direct oversight by both UT-Austin supervisory staff and MPR engineers was evident and effective.

14.0 Meetings, Including Exit

On June 27, 2013, the team conducted an exit meeting to discuss the preliminary findings and observations with Mr. Kevin Walsh, Site Vice President, and other members of Seabrook Station staff. The inspectors verified that no proprietary information was retained by the inspectors or documented in this report.

SUPPLEMENTAL INFORMATION

KEY POINTS OF CONTACT

Licensee Personnel
B. Brown, Design Engineering Manager
A. Chesno, Performance Improvement Manager
K. Chew, License Renewal Engineer
R. Cliché, License Renewal Project Manager
M. Collins, Design Engineering Manager
J. Connolly, Site Engineering Director
R. Noble, Project Manager
M. O'Keefe, Licensing Manager
T. Vassallo, Principal Design Engineer
K. Walsh, Site Vice President
P. Willoughby, Licensing Engineer

LIST OF ITEMS OPENED, CLOSED, DISCUSSED, AND UPDATED

Updated
None

Opened
None

Closed
None

LIST OF DOCUMENTS REVIEWED

Procedures
Maintenance Rule Scoping Document, Revision 0
EDS 36180, Structures Monitoring Program, Revision 0, 1, 2

Corrective Action Documents (AR)
1651969, 1629504, 574120, 581434, 1636419, 1673102, 1647722, 1664399, 1677340, 1687932, 1692374, 1698739, 1755727, 1757861, 1819080, 1804477, 1819069

Drawings

Licensing and Design Basis Documents and Calculations
Seabrook Station UFSAR, Revision 14
ACI 318-71
Calculation CD-20
Calculation CD-18
Calculation C-S-1-10168

Miscellaneous Documents
FP 100348, Statistical Analysis-Concrete Compression Test Data (PTL)
FP 100642, Scope for Alkali-Silica Reaction Walkdowns
FP 100641, Procedure for ASR Walkdowns and Assessment Checklist
FP 100661, Compression Testing Concrete Cores (WJE)
FP 100696, Material Properties of ASR-Affected Concrete
FP 100700, Field Investigation
FP 100705, Structure ASR Walkdown Report (MPR 0326-0058-58)
FP 100714, Three Dimensional Dynamic Analysis of Containment Enclosure Building
FP 100715, ASR Impact Study on Containment Enclosure Building
FP 100716, Interim Assessment: Impact of ASR on Structures (MPR-3727)
FP 100717, ACI 318-71 Perspectives
FP 100718, Anchor Test Report (MPR-3722)
FP 100720, Crack Index and Expansion Measurement
FP 100738, Measurements for ASR Crack Indexing on Concrete Structures
FP 100697, MPR 0326-0058-53, White Paper on Structural Implications of ASR: State of the Art, Revision 1
MPR 0326-0058-83, Shear Screening Criteria Used in MPR-3727
FHWA-HIF-09-004, Federal Highway Administration, "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction in Transportation Structures."

Documents Reviewed at FSEL

1. Purchase Order No. 0326 – 0058 -25, dated December 1, 2011 and change order Nos. 1, dated March 21, 2012; No. 2, dated March 27, 2012; No. 3, dated July 23, 2012; and No. 4, August 2, 2012 between MPR Associates Inc. and Ferguson Structural Engineering Laboratory as applied to Anchor Testing Program

2. Contract No. 02293285, dated June 6, 2011, and Amendment Nos. 1, dated October 25, 2011; No. 2, dated December 17, 2011; No. 003, dated January 3, 2012; No. 004, dated February 27, 2012; Amendment 6, dated July 26, 2012, between NextEra and MPR Associates Inc.

3. MPR Letter to Ferguson Structural Engineering Laboratory, dated December 1, 2011, Notice of Intent to Contract for Testing of Anchors in ASR-affected Concreter – authorizing FSEL to develop project-specific quality system manual, implementing procedures for testing and perform initial characterization of the ASR degradation on girders.

4. MPR Letter to Ferguson Structural Engineering Laboratory, dated December 1, 2011, Research on Performance of Anchors in ASR-affected Concrete

5. MPR Letter to Ferguson Structural Engineering Laboratory, dated March 27, 2012, Research on Performance of Anchors in ASR-affected Concrete

6. MPR Letter to Ferguson Structural Engineering Laboratory, dated July 23, 2012, Research on Performance of Anchors in ASR-affected Concrete

7. MPR Letter to Ferguson Structural Engineering Laboratory, dated August 2, 2012, Research on Performance of Anchors in ASR-affected Concrete

8. MPR Letter to Ferguson Structural Engineering Laboratory, dated October 26, 2012, Research on Performance of Anchors in ASR-affected Concrete

9. Purchase Order No. 0326 – 0063 -01, dated June 4, 2012, between MPR Associates Inc. and Ferguson Structural Engineering Laboratory as applied to Beam Testing Program

10. Contract No. 02207204, dated April 27, 2012, NextEra and MPR Associates Inc., related to ASR Concrete Beam Testing Program (for Shear and Lap-splice anchorage)

11. Project Plan 0326 – 0062 -01, Revision 0, dated May 1, 2012, by MPR Associates Inc. as applied to Beam Testing Program

LIST OF ACRONYMS

ACI	American Concrete Institute
ADAMS	Agencywide Documents Access and Management System
AMP	Aging Management Program
AR	Action Request
ASME	American Society of Mechanical Engineers
ASR	Alkali-Silica Reaction
BRE	Building Research Establishment
CAL	Confirmatory Action Letter
CCI	Combined Crack Index
CEB	Containment Enclosure Building
CFR	Code of Federal Regulations
CW	Circulating Water
DCR	Demand to Capacity Ratios
DGB	Diesel Generator Building
DRI	Damage Rating Index
DRP	Division of Reactor Projects
DRS	Division of Reactor Safety
EDG	Emergency Diesel Generator
EFW	Emergency Feedwater
EPRI	Electric Power Research Institute
EOC	Extent-of-Condition
ET	Electric Tunnel
EV	Equipment Valve
FEA	Finite Element Analysis
FHWA	Federal Highway Administration
FP	Foreign Print
FPL	Florida Power and Light
FSEL	Franklin Structural Engineering Laboratory
IMC	Inspection Manual Chapter
IP	[NRC] Inspection Procedure
LF	Load Factor
MPR	MPR Associates, Inc.
NRC	Nuclear Regulatory Commission
PARS	Publicly Available Records
P&ID	Piping and Instrument Diagram
PM	Preventative Maintenance
POD	Prompt Operability Determination
PRA	Probabilistic Risk Assessment
psi	pounds per square inch
QA	Quality Assurance
RCA	Radiologically Controlled Areas
RCE	Root Cause Evaluation
RHR	Residual Heat Removal
SDP	Significance Determination Process
SG&H	Simpson, Gumpertz & Heger

SMP	Structures Monitoring Program
SRI	Senior Resident Inspector
UFSAR	Updated Final Safety Analysis Report
UT-A	University of Texas - Austin
UK	United Kingdom
WO	Work Orders

From:	Erickson, Alice
To:	Marshall, Michael
Subject:	SBK Inspection Report Follow-up
Date:	Thursday, August 01, 2013 7:34:00 AM
Attachments:	IR 2012-010 draft 7-23-13 - AE comments.docx

Good Morning Michael,

I've added a comment to Section 11 to address the Region's reference to a LR commitment. I'll stop by quick before I go to training.

Alice Erickson
Structural Engineer
Office of Nuclear Reactor Regulation
Division of License Renewal
Aging Management of Structures, Electrical, and Systems Branch

Mail Stop: O-11F1
Phone: (301) 415-1933
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B139

ENCLOSURE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
2100 RENAISSANCE BOULEVARD, SUITE 100
KING OF PRUSSIA, PENNSYLVANIA 19406-2713

Mr. Kevin Walsh
Site Vice President
Seabrook Nuclear Power Plant
NextEra Energy Seabrook, LLC
c/o Mr. Michael Ossing
P.O. Box 300
Seabrook, NH 03874

SUBJECT: SEABROOK STATION, UNIT NO. 1 - CONFIRMATORY ACTION LETTER FOLLOW-UP INSPECTION - NRC INSPECTION REPORT 05000443/2012010

Dear Mr. Walsh:

On June 27, 2013, the U. S. Nuclear Regulatory Commission (NRC) completed a team inspection at Seabrook Station, Unit No. 1. The enclosed inspection report documents the inspection results, which were discussed with you and other members of your staff.

The team inspection examined activities conducted under your license as they relate to safety and compliance with the Commission's rules and regulations and with the conditions of your license. Specifically, the team reviewed selected procedures and records, observed activities, and interviewed station personnel regarding the adequacy of NextEra's actions to address the impact of Alkali-Silica Reaction (ASR) on reinforced concrete structures. The team reviewed selected Confirmatory Action Letter (CAL) 1-2012-002 commitments for adequacy and closure.

The NRC determined that the eleven actions committed to in CAL have been satisfactorily completed. The team independently verified that NextEra had appropriately assessed and determined that all ASR affected structures remain operable. The team also confirmed that your root cause evaluation was thorough and identified appropriate corrective actions.

Many important corrective actions necessary to resolve this issue are currently in progress. These actions include your planned two year test program of ASR affected large scale concrete specimens at the University of Texas, Ferguson Structural Engineering Laboratory (FSEL). Therefore, while our review of the CAL items was completed during this inspection, the NRC will continue to provide oversight of both NextEra's testing program at the FSEL and onsite ASR related activities. Our final decision regarding closure of the CAL will be provided to NextEra in a future correspondence.

Comment [A1]: Is DLR planning to do this, or the Region?

Comment [A2]: Why is the final decision going to be in a future correspondence? In several paragraphs, we state that the CAL items were reviewed and closed.

It should be noted that the inspection team results are based solely on Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 requirements. The NRC is currently in the process of conducting a separate review of the ASR issue as part of the license renewal process in accordance with 10 CFR Part 54. As such, certain aspects of the ASR issue discussed may also have applicability to the license renewal review and involve additional consideration and require additional information beyond that discussed in this report.

In accordance with 10 CFR 2.390 of the NRCs "Rules of Practice," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of the NRC's document system (ADAMS). ADAMS is accessible from the NRC website at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

Raymond K. Lorson, Director
Division of Reactor Safety

Docket No. 50-443
License No: NPF-86

Enclosures:
1. Inspection Report No. 05000443/2012010
   w/ Attachment: Supplemental Information
2. Confirmatory Action Letter 1-2012-002

cc w/encl: Distribution via ListServ

It should be noted that the inspection team results are based solely on Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 requirements. The NRC is currently in the process of conducting a separate review of the ASR issue as part of the license renewal process in accordance with 10 CFR Part 54. As such, certain aspects of the ASR issue discussed may also have applicability to the license renewal review and involve additional consideration and require additional information beyond that discussed in this report.

In accordance with 10 CFR 2.390 of the NRCs "Rules of Practice," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of the NRC's document system (ADAMS). ADAMS is accessible from the NRC website at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

Raymond K. Lorson, Director
Division of Reactor Safety

Docket No. 50-443
License No: NPF-86

Enclosures:
1. Inspection Report No. 05000443/2012010
   w/ Attachment: Supplemental Information
2. Confirmatory Action Letter 1-2012-002

cc w/encl: Distribution via ListServ

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DATE	/ /13	/ /13	/ /13	

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U.S. NUCLEAR REGULATORY COMMISSION

REGION I

Docket No.:	50-443
License No.:	NPF-86
Report No.:	05000443/2012010
Licensee:	NextEra Energy Seabrook, LLC
Facility:	Seabrook Station, Unit No. 1
Location:	Seabrook, New Hampshire 03874
Dates:	November 3, 2012 to April 30, 2013
Inspectors:	W. Cook, Team Leader, Division of Reactor Safety (DRS) S. Chaudhary, Reactor Inspector, DRS W. Raymond, Senior Resident Inspector A. Buford, Structural Engineer, Division of License Renewal (DLR), Office of Nuclear Reactor Regulation (NRR) G. Thomas, Structural Engineer, Division of Engineering, NRR A. Sheikh, Senior Structural Engineer, DLR, NRR N. Floyd, Reactor Inspector, DRS
Approved by:	James Trapp, Chief, Engineering Branch 1 Division of Reactor Safety

SUMMARY OF FINDINGS

IR 05000443/2012010; 11/03/2012 - 06/27/2013; Seabrook Station, Unit No. 1; Confirmatory Action Letter (CAL) Follow-up Inspection Report.

This report covered several weeks of onsite inspection at Seabrook Station, two weeks of inspection at the Ferguson Structural Engineering Laboratory (FSEL) University of Texas – Austin, and periodic in-office reviews, over the past eight months, by region based inspectors and headquarters reviewers to assess the adequacy of actions taken by NextEra to address the occurrence of Alkali-Silica Reaction (ASR) in reinforced concrete structures at Seabrook Station. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process," Revision 4, dated December 2006.

Comment [A3]: Recommend using the same wording from the cover letter (highlighted) for consistency.

Cornerstone: Mitigating Systems

During this second CAL follow-up inspection, the team examined the remaining six commitments documented in CAL No. 1-2012-002, dated May 16, 2012. The CAL items reviewed and closed during this inspection were 2, 4, 7, 8, 9 and 11. In addition, a number of observations documented in the first CAL follow-up inspection (NRC Inspection Report 05000443/2012009, Section 9.0) were reviewed and closed in this report. Closure of CAL Item 7 was administrative, in that, NextEra had withdrawn this commitment by letter dated December 13, 2012 (ML12362A323). NextEra's revision to this commitment was approved by the NRC as documented in the CAL revision letter, dated January 14, 2013 (ML13014A555). Our assessment of CAL Item 7 and the remaining CAL items reviewed and closed are documented in the enclosed inspection report.

The review and closure of each CAL item signifies the NRC's satisfactory assessment of NextEra's commitments and planned corrective actions to address the non-conforming alkali-silica reaction in Seabrook reinforced concrete structures. However, the completion of the CAL follow-up inspections is not the completion of NRC review and oversight of NextEra's actions to address the ASR issue. As discussed in the team's review of CAL Item 4 and the revised ASR Project Corrective Action Plan (CAP), NextEra has implemented a number of ongoing activities, in addition to the FSEL testing program to address ASR-affected structures. The details of the NRC's plans to oversee these activities will be addressed separately.

Comment [A4]: Recommend deleting, or adding the word "condition,"

Comment [A5]: ??? We don't have detailed plans to do this, do we?

NextEra's root cause evaluation (CAL Item 2) appropriately identified the significant causal and contributing factors resulting in ASR impacting reinforced concrete structures at Seabrook Station. NextEra's ASR Project CAP (CAL Item 4) sufficiently captures the numerous corrective actions taken and planned to address the ASR non-conforming condition, and remains a "living document" to track the resolution of ASR at Seabrook Station.

Mortar Bar Testing (CAL Item 6, reference NRC Inspection Report 05000443/2012009) was successfully completed and the results indicated sufficient reactive silica and alkali in the Seabrook structures to fuel the progression of ASR for the foreseeable future. Consequently, NextEra withdrew their commitment for Prism Testing (CAL Item 7) and the NRC staff administratively closed this commitment. The team reviewed NextEra's large specimen testing program technical specifications (CAL Item 8) and anchor testing program description (CAL Item 11) and concluded that these programs were sufficiently developed and described to support an appropriate understanding of the testing plans and objectives.

NextEra implemented a number of enhancements to the Structures Monitoring Program (CAL Item 9) to adequately monitor the progression of ASR, pending the completion and evaluation of results from the large specimen testing program. The team concluded these monitoring actions were consistent with currently available industry practices.

Lastly, the team reviewed and closed a number of observations discussed in the first CAL Follow-up Inspection, including: pending structural evaluations (13); containment POD observations; core sample material property testing; quantification of pre-stressing effects of ASR expansion; additional rebar examinations; crack indexing use in the SMP; and Phase 3 walkdown plans and schedule.

REPORT DETAILS

1.0 Background

Alkali-Silica Reaction (ASR) is a chemical reaction occurring in hardened concrete that can change the physical properties of concrete and affect structural performance. In June 2009, NextEra identified potential degradation in below-grade concrete structures at Seabrook. In August 2010, NextEra completed petrographic evaluation of concrete core samples, which confirmed ASR as the degradation mechanism. The degraded condition in numerous Seabrook Category I structures was evaluated in the Corrective Action Program via prompt operability determinations (PODs). The PODs were revised as new information became available and improved analytical techniques were incorporated.

NextEra initially used the results of mechanical testing of concrete cores to assess the degree of structural degradation due to ASR. This is a traditional method described in American Concrete Institute (ACI) 228.1R, "In-Place Methods to Estimate Concrete Strength," for assessing existing concrete structures. NextEra tested the cores for compressive strength and elastic modulus. NextEra used the methods defined in construction and design code ACI 318-1971, "Building Code Requirements for Reinforced Concrete," to evaluate the structural capacity (operability) of the ASR-affected structures. However, the mathematical relationships in ACI-318 are based on empirical data from testing of non-degraded concrete, and these relationships may not be valid for ASR-affected concrete.

After further review of industry experience and literature pertaining to ASR, NextEra engineering concluded that the core test data was not indicative of structural performance of ASR-affected reinforced concrete structures. NextEra's engineering evaluation stated that once the cores are removed from the structure, concrete core samples are no longer subject to the strains imposed by the ASR-related expansion or restraints imposed by the steel reinforcing cage. The engineering evaluation also stated that confinement provided by steel reinforcing bars (rebar) and other restraints limit ASR expansion of the concrete within the structure and thereby limit the adverse impact on structural performance. Therefore NextEra engineering concluded that the reduction of mechanical properties observed in mechanical testing of cores was not representative of in-situ concrete performance. Based on this conclusion, NextEra suspended taking core samples to evaluate the concrete mechanical properties of structures impacted by ASR and revised the operability assessment approach. NextEra's current approach for assessing structural integrity and operability is to compare available design margins to an assumed reduction in structural capacity due to ASR.

NextEra's operability evaluations were based upon an examination of available design margins and a presumed ASR-caused reduction in structural design capacity for critical limit states. The details of this methodology and related assumptions were developed in NextEra's Interim Assessment (FP 100716). The assessment assumed lower bound values of structural capacity for ASR-affected concrete for limit states based on research test data, primarily from small scale test specimens. The assessment focused on the structural limit states that are the most sensitive to ASR effects (i.e., out-of-plane shear capacity, lap splice development length, and anchorage capacity). The assessment determined the structures were suitable for continued service. A final operability assessment will be conducted by NextEra following evaluation of structural performance based on a proposed large scale testing program of beam specimens representative of Seabrook reinforced concrete structures. The test program has been initiated at the Ferguson Structural Engineering Laboratory at the University of Texas at Austin (UT-A), with some testing (anchors) commenced in 2013 and large beam testing scheduled to be completed by 2015. Based upon the slow progression of the ASR expansion, the current operability evaluations, coupled with the Structures Monitoring Program six-month combined crack indexing, provide reasonable assurance of continued structural operability until the testing program is completed.

2.0 Confirmatory Action Letter 1-2012-002

Confirmatory Action Letter 1-2012-002, dated May 16, 2012, was written to confirm commitments by NextEra (established during a meeting with NRC management and staff on April 23, 2012) with regard to planned actions to evaluate ASR-affected reinforced concrete structures at Seabrook Station. In response to the CAL, NextEra committed to provide information to the NRC staff to assess the adequacy of NextEra's corrective actions to address this significant condition adverse to quality. CAL 1-2012-002 is provided as an Enclosure to this report. The NRC staff also formed a working group to provide appropriate oversight of NextEra's activities to address ASR and to coordinate NRC inspection and review activities. The ASR Working Group Charter (ML121250588) outlines the regulatory framework and general acceptance criterion for NRC oversight and review of this issue. As documented in NRC Inspection Report No. 05000443/2012009, dated December 3, 2012 (ML12338A283) CAL Items 1, 3, 5, 6, and 10 were closed.

Based on the results of this inspection, the remaining six CAL Items 2, 4, 7, 8, 9, and 11 are closed.

3.0 Review of Alkali-Silica Reaction Root Cause Evaluation (CAL Item 2)

Inspection Scope

As documented in Inspection Report No. 05000443/2012009, the team reviewed NextEra's response to CAL Item 2, "Submit the root cause for the organizational causes associated with the occurrence of ASR at Seabrook Station and related corrective actions by May 25, 2012." The licensee submitted their root cause evaluation (RCE) in a letter to the NRC dated May 24, 2012 (ML12151A396). Based upon the team's initial review, the inspectors concluded that the second root cause identified was not sufficiently characterized in NextEra's May 24, 2012, submittal. Specifically, NextEra did not clearly describe the personnel and organizational factors that contributed to inadequacies in the Structures Monitoring Program (SMP) and the failure of the Seabrook staff to have identified ASR degradation of reinforced concrete structures sooner. The team discussed this observation with the responsible Seabrook staff and NextEra determined that a revision to the RCE was warranted and revised the RCE to more appropriately develop and characterize this second root cause and the associated corrective actions.

NextEra submitted a revised RCE summary for NRC review in a letter dated May 1, 2013, (ML13151A328, Enclosure 1). The team reviewed the revised RCE summary for clarity and appropriateness of associated corrective actions, consistent with guidance outlined in 10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Action," and NextEra's Corrective Action Program (CAP).

Findings and Observations

The team identified no findings. Based upon the team's review, CAL Item 2 is closed.

As documented in Enclosure 1 to the May 1, 2013 letter, NextEra summarized the two root causes, as follows: RC1 – the ASR developed because the concrete mix design unknowingly utilized a coarse aggregate that would, in the long term, contribute to ASR. Although the testing was conducted in accordance with American Society for Testing and Materials (ASTM) standards, those testing standards were subsequently identified as limited in their ability to predict slow reactive aggregate that produced ASR in the long term; and RC2 – based on the long standing organizational belief that ASR was not a credible failure mode due to the concrete mix design, dispositions for Condition Reports involving groundwater intrusion or concrete degradation, along with the structures health monitoring program did not consider the possibility of ASR development. In addition, NextEra identified a contributing cause involving the failure of the organization to prioritize groundwater elimination or mitigation resulting in more concrete area exposed to moisture.

The team verified that NextEra had appropriately identified the root cause(s). The ASTM concrete aggregate testing standards in effect at the time of plant construction were properly implemented, but later determined to be ineffective in identifying slow reacting, ASR susceptible aggregates. Those standards were subsequently revised by the industry and adopted by NextEra to prevent recurrence. NextEra's RCE concluded that the Structures Monitoring Program (SMP) did not remain current with concrete industry operating experience and associated failure modes, such as ASR. Contributing to the shortcomings in the SMP to have identified this concrete degradation mechanism earlier was the "organizational mindset" that the groundwater in-leakage was an operational nuisance and nothing more. Consequently, station and engineering staffs were insensitive to the potential detrimental effects of the ground water infiltration and did not assess the long term impact on station structures. The team concluded that NextEra's implementation of a broad periodic review process to ensure all systems and component monitoring programs remain current and effective was determined an appropriate corrective action for this causal factor.

4.0 Integrated Corrective Action Plan (CAL Item 4)

Inspection Scope

CAL No. 1-2012-002 documented NextEra's commitment to submit by June 8, 2012, a corrective action plan for the continued assessment of ASR in concrete structures at Seabrook Station including development of remedial actions to mitigate the effects of ASR, where warranted. By letter dated June 8, 2012 (ML12171A227), NextEra submitted their integrated corrective action plan (CAP) for NRC review. The CAP outlined the major elements of diagnosis, evaluation, prognosis and mitigation of ASR-affected structures as understood at the time. Since June 8, 2012, NextEra has made considerable progress in refining the elements of this plan, implementing the initial phases, and more clearly defining and focusing future actions. NextEra provided an updated ASR Project CAP in a letter dated May 1, 2013 (ML13151A328, Enclosure 2) to document these plan changes.

During this inspection period, the team conducted numerous discussions, meetings, and conference calls with NextEra, as well as onsite inspections at both Seabrook Station and UT-Austin to review NextEra's actions to address the ASR-affected reinforced concrete structures. From these interactions, the CAP has developed greater clarity of the necessary steps (corrective actions) to address this non-conforming condition impacting safety-related reinforced concrete structures. As previously documented in Inspection Report 05000443/2012009 and detailed in other sections of this report, the team assessed the adequacy of completed and ongoing ASR-related activities identified in the integrated CAP, consistent with guidance outlined in 10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Action," and NextEra's Quality Assurance Program.

Findings and Observations

The team identified no findings. Based upon the team's review, CAL Item 4 is closed. NextEra's ASR project staff stated that they plan to maintain the ASR Project CAP as a "living document" and will update it periodically to capture completion of activities and add new actions, as appropriate.

5.0 Prism Testing Commitment Withdrawn (CAL Item 7)

Inspection Scope

CAL Item 7 committed NextEra to "Complete long term aggregate expansion testing (ASTM C 1293, Concrete Prism Test) by June 30, 2013." The purpose of this CAL item was to determine, in conjunction with the Mortar Bar Testing (CAL Item 6), if the coarse aggregate contributing to ASR in Seabrook reinforced concrete still contained sufficient reactive silica for the alkali-silica reaction to continue long-term under the existing environmental conditions. Alternatively, these tests could demonstrate that the progression of ASR at Seabrook maybe self-limiting due to the depletion of reactive silica in the concrete. The Prism Test (as defined by ASTM C1293) involves monitoring the expansion (by measurement of specimen elongation due to ASR) of the test specimen (a molded concrete brick approximately 3 by 5 by 12 inches in length) over a one year period. Expansion in excess of 0.04% is considered potentially deleterious and a positive test for slow reactive aggregate. The Prism Test is similar to the Mortar Bar Test (reference ASTM C1260), but has a duration of 14 days and an expansion limit of 0.1%.

Based upon the results of the completed Mortar Bar Expansion Testing (reference NRC Inspection Report No. 05000443/2012009, Section 5.0), NextEra concluded that the available quantities of silica in the concrete would not be depleted in the near term and that additional confirmatory testing via the Prism Test method was not warranted. NextEra ran the Mortar Bar Test several weeks beyond the 14-day test (terminated after 103 days) and observed that the alkali-silica reaction was still progressing at the conclusion of the test, indicating the presence of sufficiently reactive aggregate to maintain ASR for a longer period of time. The team noted that the Mortar Bar Test involved the reuse of aggregates from Seabrook test cores (concrete that had already experienced appreciable ASR) and similar aggregate from concrete not affected by ASR. The side-by-side comparison of the test specimens showed no appreciable difference in ASR progression or observed expansion rates. Accordingly, NextEra concluded the Prism Test would add no significant knowledge to the condition assessment of Seabrook concrete. NextEra concluded that all Seabrook reinforced structures are or may be affected by ASR, unless specifically ruled-out by further analysis, such as petrographic examination. By letter dated December 13, 2012, NextEra requested that CAL Item 7 be deleted. As documented in NRC letter dated January 14, 2013 (ML13014A555), the NRC accepted NextEra's technical basis for deleting CAL Item 7.

Findings and Observations

No findings were identified. CAL Item 7 is administratively closed.

6.0 Review of Technical Details of Large Specimen Testing Program (CAL Item 8)

Inspection Scope

CAL Item 8 committed NextEra to "Submit the technical details of the testing planned at the contracted research and development facility by June 30, 2012." By letter dated June 21, 2012, (ML12179A281) NextEra submitted the Shear and Lap Splice Testing overview prepared by the Ferguson Structural Engineering Laboratory (FSEL) at the University of Texas at Austin, dated March 15, 2012. The purpose of the test program, as described in the FSEL document, is to provide sufficient data and insights to establish the current and future implications of ASR on Seabrook reinforced concrete structures. Based upon limited available literature or test data relative to the impact of ASR on walls without transverse reinforcements (the majority of Seabrook ASR-affected structures) destructive testing of ASR-affected test specimens will be conducted to evaluate the impact of ASR on out-of-plane shear strength and lap splice development. The test specimens being prepared at FSEL will be of representative scale and design, such that the test results may be correlated to Seabrook structures.

The team reviewed the June 21, 2012 submittal and conducted a conference call on December 18, 2012, with the NextEra and UT-Austin FSEL staff to discuss the merits of the proposed test program. Based upon the complexity of the information discussed and follow-up inspection activities, NextEra prepared a test program overview document and a detailed test specification to supplement the June 21, 2012, CAL response letter. By letter dated May 1, 2013 (ML13151A328 redacted and ML13151A291 un-redacted) NextEra provided the NRC with the "Seabrook Station - Specification for Shear and Reinforcement Anchorage Testing of ASR-Affected Reinforced Concrete," (Enclosures 3 & 4) and "Approach for Shear and Reinforcement Testing of Concrete Affected by Alkali Silica Reaction," (Enclosure 5 & 6). Each of these documents has a proprietary and non-proprietary version.

The team reviewed the revised testing specification and the associated overview document to verify that the overall test program approach and application of test results would reasonably address the Seabrook ASR-affected concrete non-conforming condition. The team discussed the test program with the FSEL, MPR and responsible NextEra engineering staffs.

Findings and Observations

No findings were identified. Based upon team review of the submitted testing program documents and related inspection activities, the team concluded that NextEra has provided a satisfactory explanation of the proposed large-scale specimen testing program, and CAL Item 8 is closed.

The team concluded that NextEra's approach has technical merit. However, as documented in NextEra's ASR Project CAP (ML 13151A328, Enclosure 2) the acceptance of the testing results to resolve ASR concerns associated with design basis structural calculations will follow the regulatory process for approval and will include evaluations pursuant to 10 CFR 50.59 and 10 CFR 50.90. As stated above, the submitted test plans satisfy NextEra's commitment to explain the scope and depth of the large-scale specimen testing program.

7.0 Review of Structures Monitoring Program (CAL Item 9)

Inspection Scope

CAL Item 9 committed NextEra to implement an update to the Maintenance Rule (10CFR50.65) Structures Monitoring Program (SMP) to include monitoring requirements for selected locations in areas that exhibit ASR by July 15, 2012. NextEra issued Revision 2 to Structural Engineering Standard 36180, "Structural Monitoring Program," effective July 12, 2012. The primary changes incorporated in Revision 2 to the SMP were: 1) performing periodic (every six months) crack indexing measurements at 26 locations to collect quantitative information on the progression of ASR expansion/degradation; 2) establishing crack width (1.0 mm or greater) and Combined Crack Index (1.0 mm/m or greater) thresholds for conducting structural evaluations (reference Foreign Print 100716, Seabrook Station: Impact of ASR on Concrete Structures and Attachments); and 3) the addition of Federal Highway Administration (FHWA) document FHWA-HIF-09-004, "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction in Transportation Structures," dated January 2010, as a reference.

The team reviewed the adequacy of these changes to the SMP to monitor ASR in Seabrook reinforced concrete structures. While not endorsed by the NRC or committed to by NextEra in Seabrook's licensing basis, the team used the American Concrete Institute (ACI) Committee Report 349.3R-96, "Evaluation of Existing Nuclear Safety-Related Concrete Structures," as a reference to assess the adequacy of the revisions made to the SMP for monitoring the progression of ASR.

Based in part on NRC observations, NextEra issued Revision 3 to the SMP on April 30, 2013. The principle changes in Revision 3 of the SMP are: 1) the addition of periodic (every 30 months) combined crack indexing (CCI) measurements at 72 discrete locations identified as Tier II (Acceptable with Deficiency) areas (CCI values between 0.5 mm/m and 1.0 mm/m, or crack widths greater than 0.2 mm, but less than 1.0 mm) to collect quantitative information on the progression of ASR expansion/degradation (this monitoring was being performed, but not documented in the SMP); and, 2) inclusion of the periodic ground water sampling program for monitoring of chemical attributes detrimental to concrete structures. During follow-up discussion with the NextEra staff, the team noted that NextEra is considering additional SMP revisions, dependent upon the results of the large specimen test program and further engineering evaluation. One of the revisions involves the installation of deep pins for monitoring of expansion in the out-of-plane direction (reference NextEra's May 1, 2013, Response to Confirmatory Action Letter (ML13151A328) Enclosure 2, ASR Project Corrective Action Plan).

Findings and Observations

The team identified no findings in this area. CAL Item 9 is closed.

The team noted that changes made to the SMP to address ASR were generally consistent with the evaluation and monitoring methods outlined in ACI 349.3R-96. The team confirmed that NextEra had incorporated a three-tiered visual inspection criteria, as outlined in Sections 5.1 through 5.3 of ACI 349.3R-96. NextEra has also augmented this visual inspection criteria with periodic (six-month and 30-month interval) CCI measurements and associated structural evaluation thresholds based upon direct measurement (CCI) results. The CCI monitoring, performed at 98 selected locations (including containment) was implemented by NextEra based upon this method being a readily measurable indicator of ASR related progression and based, in part, upon endorsement by FHWA and outlined in FHWA-HIF-09-004.

The crack growth monitoring provides a visual indication of the progression of ASR within a reinforced concrete structure. The relative width and number of visible cracks may be correlated to the overall progression of ASR and may be used to evaluate ASR impact on structural performance. However, ASR cracking and crack propagation is closely associated with the specific reinforcement design and structural loading. Accordingly, the adequacy of CCI measurement as a long term structures monitoring methodology for Seabrook structures is being further evaluated by NextEra as part of the UT-Austin FSEL testing program. The results of the UT-Austin testing program is intended to be used to validate this methodology for application at Seabrook.

Evaluation of infiltration water chemistry and groundwater monitoring: ACI 349.3R-96 discusses environmental monitoring and related effects of aggressive water chemistry, including the potential for leaching. Accordingly, NextEra has integrated the periodic monitoring of ground water chemistry into the SMP (reference Revision 3, dated 4/30/2013, Attachment 4). NextEra plans to investigate the expansion of the water chemistry monitoring program (reference AR No. 1758920-40) to include periodic analysis of infiltrated water (water that has migrated through below grade reinforced concrete walls). The establishment of an initial baseline analysis and continued periodic monitoring could provide some relative trend data for further evaluation and follow-up actions, as appropriate.

The team concluded that the implemented and planned SMP enhancements provide NextEra with an improved program to assess the extent and degree of ASR progression and to more thoroughly monitor the environmental factors contributing to ASR. NextEra's initial SMP revision (Revision 2) was adequate; however, the SMP Revision 3 enhancements include multiple activities that are better aligned with ACI 349.3R guidance.

Comment [A6]: I don't think it's necessary to find a prior version of the SMP adequate.

8.0 Review of Anchor Testing Program (CAL Item 11)

Inspection Scope

The micro-cracking caused by ASR may adversely impact the structural capacity of anchors that support safety-related piping, cable trays and other components. NextEra's initial operability determinations were supported by anchor performance testing conducted on available ASR degraded specimens previously fabricated at or obtained by FSEL, UT-Austin (reference FP 100718). As documented in Inspection Report 05000443/2012009, the initial testing demonstrated satisfactory performance of the anchors in ASR-affected concrete during the earlier stages of ASR progression. NextEra's evaluation also stated that the eventual reduction in capacity due to ASR was sufficiently offset by established anchor manufacturer's design margins (FP 100716). However, based upon the limitations of the testing performed (on ASR-affected test specimens of different composition and compressive strength than Seabrook reinforced concrete structures) NextEra planned to conduct additional testing. The planned testing involves anchors installed (both during specimen fabrication and post-fabrication) in ASR-affected test specimens that more closely replicate the reinforced concrete structures and anchor configurations at Seabrook.

By licensee letter dated December 13, 2012, (ML12362A323) NextEra requested a revision to CAL Item 11 to address a schedule challenge to the targeted anchor testing program completion date. NextEra also proposed redefining CAL Item 11 to be consistent with the wording of CAL Item 8, regarding large-scale specimen testing. Specifically, NextEra revised their commitment to read, "Submit technical details of the anchor test program planned at the contracted research and development facility by February 28, 2013." The original commitment read, "Complete anchor test program by December 31, 2012. Results will be available for NRC review approximately 30 days after testing is complete." Based upon unexpected specimen fabrication delays and the slow progression of accelerated ASR aging, NextEra identified that it would not be possible to complete the anchor testing per the original commitment date. The NRC accepted NextEra's revised commitment, as documented in NRC letter dated January 14, 2013 (ML13014A555).

The team reviewed the details and adequacy of NextEra's anchor testing program as outlined in the proprietary "Anchor Testing Program Overview," dated February 26, 2013. The anchor testing program overview and associated testing specifications were docketed for NRC review via NextEra letter dated February 28, 2013 (ML13088A218 redacted and ML13088A229 un-redacted, dated March 15, 2013). The technical overview document and accompanying specifications outline the major elements of the proposed anchor testing program, including the key attributes of the fabrication of the test specimens, monitoring of the specimens as accelerated ASR aging progresses, and the details of the testing of individual anchor bolt configurations.

Findings and Observations

The team identified no findings. Based upon the team's review, CAL Item 11 is closed.

During the team's visits to the UT-Austin FSEL, the team observed the conditions and controls implemented for the aging of the test blocks and testing of concrete sample cylinders for compressive strength and modulus of elasticity. The team witnessed appropriate implementation of the testing procedures by FSEL staff and proper oversight of these activities by the MPR quality assurance staff.

At the conclusion of this inspection, the desired level of ASR progression in the test blocks had not been achieved to conduct the first round of ASR-affected anchor testing. The team reviewed the results of the control specimen anchor testing completed in November 2012. The purpose of the control specimen testing was to establish a baseline to determine the potential reduction in anchor bolt capacity due to ASR. Review of the test data (reference MPR Memorandum DRN 0326-0058-163, dated June 18, 2013) identified that all anchor bolts test results were in agreement with calculated capacities and an appropriate baseline had been established for comparison during future testing.

9.0 Review of Previously Identified Issues of Interest

9.1 Structural Evaluations for 13 Locations

As documented in Inspection Report 05000443/2012009, NextEra identified 26 locations (including containment) as having patterned cracking with a CCI of greater than 1.0 mm/m. In accordance with the SMP, Revision 2, structures with a CCI of >1.0 mm/m require a structural evaluation. NextEra's Interim Assessment documented an engineering judgment that biased the performance of detailed structural evaluations to the 11 locations with a CCI > 1.5 mm/m. The locations with a CCI of between 1.0 and 1.5 mm/m (13 locations) were considered bounded by the 11 areas subjected to a detailed evaluation. The lack of a documented structural evaluation for the 13 locations with a CCI of between 1.0 and 1.5 mm/m was a minor performance deficiency which NextEra entered into the Corrective Action Program (AR 1804477 and AR 1819080). During this inspection, the team reviewed Calculation C-S-10168, Revision 1, and FP 100716, "Seabrook Station: Impact of Alkali-Silica Reaction on Concrete Structures and Attachments," Revision 2, which incorporated the additional evaluations for the 13 locations.

Comment [A7]: Recommend referencing Revision 3 instead of Revision 2.

The evaluation methodology included reviewing the original calculations that govern the design of the structures to determine the design parameters associated with the general area of ASR degradation. The structural member's load demand and capacity were then noted and the margin calculated for comparison against the potential reductions in load capacities caused by ASR. The assumed reductions in capacity were determined based on lower bound values established in industry literature. A summary of the evaluation results was provided in Table 3 of FP100716, Revision 2. For areas where design margins were insufficient to offset assumed reductions, further review was performed to recapture margin. Specifically, for two areas (Electric Tunnel and Discharge Structure), the design calculation used conservative load factors which were lowered to establish more representative demand loads, as described in Calculation C-S-1-10168, Revision 1. NextEra demonstrated additional margin to assure structural integrity despite the assumed reduction in capacity due to ASR. However, in the calculation for Electric

Tunnel area MF101 (C-S-1-10168, pg 30), NextEra reduced the hydrostatic load factor (1.4) to achieve a more realistic load demand. NextEra plans to credit the 1.4 load factor in the load demand calculation to establish full qualification per the Final Safety Evaluation Report (FSAR) licensing basis in the final operability determination, following completion of the testing program at UT-Austin.

The team concluded that NextEra's initial approach to perform a bounding analysis for areas with CCI >1.5 mm/m was not conservative, because the design margins vary in each structural member of each reinforced concrete structure. This conclusion highlights the need, once the impact of the ASR degradation on structural capacities is determined from the UT-Austin FSEL test program, for NextEra to closely review the design calculations for each ASR impacted area to assure margins remain acceptable without having to remove or reduce the load factors assumed in the current licensing basis.

9.2 Review of Core Sample Material Property Testing

As documented in Inspection Report 05000443/2012009, Section 3.2.9, the NRC planned to reexamine the need of additional core sampling of Seabrook structures for the purpose of monitoring and assessing the condition of ASR-affected reinforced concrete. For the long term, NextEra has elected to evaluate structural performance (operability) of the Seabrook ASR-affected reinforced concrete structures by developing a testing program involving large specimens that are fabricated to closely replicate the Seabrook concrete and reinforcement design. NextEra has pursued this method, instead of conducting detailed material properties testing of core samples, based upon available laboratory testing and data that indicates that measurable material properties of removed cores do not, under all circumstances, accurately represent the "in situ" mechanical properties of the concrete. The reason for the difference is that prior to removal of the core sample, that concrete specimen was subjected to the specific structural compressive stresses (dead loads, live loads, and hydrostatic loads) and reinforcement bar restraints of its location within the structural member. When removed from the structural member, that concrete specimen is wholly unrestrained. In addition, as identified in the associated core sampling standard (ASTM C42, "Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete") core sample test results may be "....affected by many factors such as the strength level of the concrete, the in-place temperature and moisture histories, the degree of consolidation, batch-to-batch variability, the strength-gain characteristics of the concrete, the condition of the coring apparatus, and the care used in removing cores."

Team review of this issue has identified two general approaches to gaining an informed understanding of the impact of ASR on reinforced concrete structures. One approach is that being taken by NextEra to assess the overall structural performance of an ASR-affected structural member, much like (but not the same) as the performance of a load test prescribed by ACI 318, "Building Code Requirements for Structural Concrete," Chapter 20, "Strength Evaluation of Existing Structures." Whereas, the alternative approach involves analytical evaluations using as an input the measureable steel and concrete material property values derived from samples from the affected structure, also recognized by ACI 318, Chapter 20. NextEra is challenged to appropriately correlate the test program results to the Seabrook structures. Accordingly, NextEra plans to take additional core samples from both the test

Comment [A8]: Is it necessary to compare the Seabrook approach to the recommendations described in Chapter 20 of ACI 318?

specimens and the Seabrook structures to better correlate the large specimen test results using petrography and mechanical testing.

9.3 Containment Prompt Operability Determination (POD) and Pre-stressing Effects of ASR

As discussed in Inspection Report 05000443/2012009, the team noted that the confinement provided by the steel reinforcement bar (rebar) cage restrains ASR expansion resulting in ASR-induced or "chemical" pre-stressing of affected structural members. The team observed that NextEra had provided a qualitative explanation of this condition in the Interim Assessment (FP 100716), and in the containment structural evaluation and prompt operability determination (POD) (AR 1804477). The team concluded that a quantitative evaluation of this condition may be warranted to address this aspect of the non-conforming ASR condition.

During this inspection, the team discussed the impact of ASR-induced pre-stressing on reinforced concrete structures with NextEra's ASR Project Team and reviewed NextEra's assessment in AR/POD 1804477. The effect of "chemical" pre-stressing is to both increase the compressive stresses in the concrete (within the rebar cage) and to increase the tensile stresses in the rebar, as long as the rebar cage restraint is sustained. Similar to fabricated pre-stressed concrete structural members, the ultimate load carrying capacity of the reinforced member is not significantly changed by the ASR-induced pre-stress. Due to pre-stressing the load sharing between the concrete and steel reinforcement bars is altered, resulting in a stiffer structure that replicates a member fabricated with higher compressive strength concrete and steel reinforcements that functions closer to established yield limits. The team concluded that the ASR-induced pre-stressing may result in some beneficial effects in terms of structural stiffness, but agreed with NextEra's engineering evaluation that this additional structural stiffness, cannot be credited for structural design purposes. Further, ASR conditions may result in the steel reinforcement strain limits being exceeded that could challenge the structural performance of the rebar.

The team noted that NextEra had not quantified the ASR induced stresses in the concrete reinforcement. The team also noted that although the crack index had been measured at three containment locations, absent quantitative analyses, NextEra has not shown that the containment reinforcement was below yield. Further, the team noted that the current design code for containment (ASME Section III, 1971) does not allow containment reinforcement strains to be above yield "……in order to keep the containment basically elastic under service load conditions and below the range of general yield under factored primary loads, the allowable stresses and strains in this subsection shall not be exceeded."

The team noted, based on measured CCI data, that it may be possible for strains in containment reinforcement to be above yield. However, this condition is not certain absent a definitive correlation between the containment CCI values and stress/strain in the rebar. This matter was discussed with NextEra representatives who stated actions would be taken (reference AR/POD 1804477) to determine the effects of ASR relative to the containment design code requirements.

The team concluded that was no significant safety concern with reinforcement strain at this time because: (1) the containment is heavily reinforced and ASR is highly localized affecting a small percentage of containment area; (2) the concrete stain (crack index) measured at the surface might not reflect the condition of the reinforcement; (3) the expansion noted at the containment location with highest crack index (mechanical penetration room, 270 degree azimuth) may be surface shrinkage and not ASR, based upon the absence of confirmatory petrography; and, (4) the integrated leak rate test in 2010 showed the containment returing to preesisting conditions. See Section 9.6 of this report, "Planned Regulatory Actions," which describes NextEra's plans to address the containment non-conforming condition within the corrective action program.

Comment [A9]: I think this statement may give the wrong impression, i.e., if they were to perform a petrographic examination and confirm ASR, would there be a significant safety concern?

9.4 Assessment of the Need for Further Rebar Examinations

As documented in Inspection Report 05000443/2012009, Section 3.2.9, the NRC reviewed the potential for ASR having an adverse impact on rebar. NextEra and their engineering consultants had concluded that rebar is unaffected by ASR-degraded concrete unless the cover concrete is severely damaged and the rebar is exposed. They concluded that in spite of the alkali-silica reaction, ample alkali would remain in the concrete to preserve the condition of the rebar and preclude a corrosive environment.

The team determined that NextEra's position was acceptable. Based upon the examination of Seabrook rebar, although limited, and review of available industry operating experience associated with reinforced concrete degradation mechanism, the team concluded that at the current level of ASR there is no evidence to suggest that the reinforcing steel bars at Seabrook are corroding. In accordance with the Seabrook SMP and their referenced American Concrete Institute 349.3R-96, "Evaluation of Existing Nuclear Safety Related Concrete Structures," periodic visual inspections (signs of leaching, staining, spalling and popouts) coupled with soil and groundwater testing for aggressive chemistry conditions (chlorides, sulfates and pH) provide appropriate monitoring and industry recommended detection methodology. Inspections conducted have not identified any iron oxide staining attributed to rebar corrosion on any ASR-affected concrete structures at Seabrook. Consequently, the team has concluded that no additional rebar examinations (removing the cover concrete to expose rebar for visual inspection) are currently warranted.

Comment [A10]: What does this mean? Recommend clarification.

9.5 Use of Combined Crack Indexing for Structures Monitoring Program

As previously documented in Inspection Report 05000443/2012009, Section 6.0, the team planned to examine NextEra's basis for using Combined Crack Indexing (CCI) as the primary SMP method to monitor the progression of ASR in Seabrook structures. The team noted that the basis for NextEra's selection of CCI for monitoring, as endorsed by the FHWA, is that CCI provides a direct visual and measurable method for the detection and monitoring of ASR progression. Although the objective of NextEra's UT-Austin testing program is to establish and correlate the degree of ASR progression to overall structural performance, the interim use of the CCI method and the 6-month interval measurements taken, to date, provide reasonable assurance that the level of degradation due to ASR remains essentially the same and that the progression rate is low. As such, the bounding engineering calculations and associated prompt operability determinations remain valid.

Best available information concerning the impact of ASR on a structural member indicates that the formation of ASR gel within the concrete matrix, and subsequent absorption of more water by that gel, results in gel expansion that generates stresses within the concrete matrix. These expansion stresses are both absorbed and transferred between the concrete and reinforcing steel bars, until eventually revealed by the patterned cracking (stress relief) on unrestrained and/or exposed surfaces of the affected structure. For structures that are not triaxially reinforced (as many of the walls at Seabrook Station, having only inner and outer surface horizontal and vertical reinforcements, but no through-wall struts or ties) the potential exist for some undetected out-of-plane crack formation and a potential undetected structural performance impact. As documented in Section 6, the large-scale testing program is intending to provide additional insights to the overall performance of these structural wall designs.

In support of the use of CCI, which is a two-dimensional concrete surface measurement, NextEra is developing plans to install deep pins in ASR-affected walls at Seabrook to better monitor ASR progression. The large scale test specimens fabricated at the UT-Austin facility include three-dimensional through-wall pin placements which will provide a more comprehensive measurement of the ASR expansion and associated impact on structural performance. NextEra hopes to install similar deep pins at the site in order to better correlate the UT-Austin testing results and the two-dimensional CCI data to actual structural performance.

As stated above, within the confines of the reinforcement cage, the ASR expansion is restrained and some of the expansion stresses are transferred to longitudinal strain in the reinforcing bars. As long as, neither the tensile strength of the concrete nor the steel rebar yield strength is compromised (exceed elastic limits), no visible cracking (stress relief) is expected. The amount of restraint imposed by the rebar cage is dependent upon the type, size and design of the rebar used. More heavily reinforced structures resist ASR expansion and may depict a different level of surface cracking compared to a lightly or non-reinforced structure with a similar degree of ASR progression.

9.6 Planned Regulatory Actions

As discussed in Section 6.0 above, and in NextEra's ASR Project CAP, the crediting the FSEL test results for demonstrating current and longer term operability of ASR-affected reinforced concrete structures will be evaluated pursuant to 10CFR50.59 and 10CFR50.90 (license amendment request). The team concluded that this approach appears reasonable and consistent with existing regulatory processes.

The team notes that Combined Crack Indexing (CCI) may become the principle method used by NextEra for monitoring the progression of ASR in affected structures. However, this method is not recognized by NRC regulatory and design standards, and is not within the current Seabrook licensing basis. Pending the results of the FSEL testing program, NextEra may propose the use of this methodology for assessing current and future operability of ASR-affected structures.

Comment [A11]: I'm not sure why the method for monitoring would have to be part of the CLB?

9.7 ASR Impact on Containment

As part of NextEra's extent of condition review, evidence of ASR was identified on the exterior surface of containment structure. NextEra initiated a prompt operability determination (No.

1804477) and concluded containment was fully operable and capable of meeting all its design basis functions, with some reduced margin. At the conclusion of this inspection, NextEra had not yet developed a plan for resolving this non-conforming condition. As this issue has been documented in the Seabrook CAP with an open operability determination, resolution of the issue will be monitored via the ROP baseline inspection activities.

10.0 Review of Six-Month Combined Crack Indexing Data

Inspection Scope

The team reviewed the periodic concrete expansion measurements for ASR-impacted Seabrook structures. Specifically, the team examined the supporting documentation for the ASR Crack Index Report dated March 18, 2013 (FP 100811) and the ASR Expansion Measurements Report dated March 18, 2013 (FP100812). The team also conducted interviews and discussions with the responsible NextEra engineering staff. The team used 10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Action," and Criterion XI, "Test Control," as the regulatory guidance to assess the adequacy of NextEra's actions to address ASR-affected reinforced concrete structures.

Findings and Observations

No findings were identified. Overall, the combined crack index (CCI) data show some evidence of continued ASR degradation, but the expansion data (pin to pin measurements) showed no significant changes. There was no change in the CCI data for the containment, but the Electric Tunnel and the Primary Auxiliary Building/Residual Heat Removal (PAB/RHR) vault both show a positive trend in CCI value in the six months since June 2012. While this may be the result of seasonal affects, ASR degradation appears to be ongoing in some Seabrook structures as indicated by some minor incremental crack growth. Collectively, the CCI measurements indicate essentially no structural changes; and therefore no challenges to the conclusions in the current ASR-affected structures' prompt operability determinations. The team noted NextEra's plans to continue the 6-month CCI measurements to establish a stable trend in observable ASR expansion for each uniquely ASR-affected structure. Continued periodic measurements should eliminate the potential influence of seasonal ambient temperature changes from the trend results.

CCI Measurements

In the ASR Crack Index Report (FP100811), NextEra measured CCI values for 26 locations in the monitoring program and compared the results to the data taken in June 2012. The CCI data shows an apparent increase in most (18 of 26) of the monitored locations. NextEra identified that the CCIs measured in December 2012 appears larger than the CCI data measured in June 2012. NextEra concluded the apparent increase in CCI values was due to seasonal temperature variations because the concrete (in December) was significantly colder, which may cause the concrete to contract between the cracks, increasing the apparent crack widths.

The team noted that 3 of 7 monitored locations on the exterior of plant buildings (above grade and more susceptible to seasonal temperature and moisture variations), showed a decrease in

CCI from June to December. Further, 15 of 18 areas showing an increase in crack index were areas monitored on interior buildings surfaces and/or below grade; and therefore less susceptible to seasonal temperature variations. In particular, the Electric Tunnel (areas 3b, 4, and 5) and the PAB/RHR Vault (areas 17, 18, 22, and 23) all show a CCI value increase of between 0.20 to 0.26 mm/m compared to June 2012. These interior, below-grade areas have been chronically wet from ground water infiltration. The team noted there was no change in the CCI values for the Containment Building (Location 14 - Mechanical Penetration MF102-01).

As reported by NextEra, uneven cracking (total crack width in one direction is much larger than in the other direction) and measured larger cracks were identified in the horizontal direction compared to the vertical. The team observed that, over the long term, averaging the horizontal and vertical CCI values may be an adequate representation of overall changes due to ASR of the specific structural member. However, the practice of averaging the horizontal and vertical CCI values is different than outlined by available industry guidance (FHWA-HIF-09-004) that recognizes the influence of reinforcements on crack growth. Thus, reporting an averaged CCI vice directional CCI values separately, could mask the expansion in a preferred direction and hamper the identification of a trend, in the short term. NextEra acknowledged this team observation and initiated a Condition Report (CR 1758920-39) to evaluate this issue.

The team also noted that NextEra revised the method of calculating CCI in the recent 6-month measurement report (December 2012). The CCI measurement reporting method was changed to account for the use of rectangular grids to determine crack index, and thereby normalize index to the total number of lines in the both directions. In so doing, NextEra recalculated the CCI values for the December 2011 and June 2012 data to eliminate potential biasing errors. The team concluded that NextEra's more consistent use of a calculation method would aid the identification of apparent trends.

<u>Structure Expansion Measurements</u>

In the Expansion Measurement Report (FP100812), NextEra performed measurements between pins embedded in the surface of plant buildings at the 26 established CCI monitoring locations. The 26 monitored locations were selected from the 131 locations identified in the ASR Walkdown Report (reference FP100705) which exhibited the highest visible ASR-associated distress. NextEra noted a null result for expansion measurements between pins in most of the 26 monitored locations. Specifically, data recorded in most (436) measurement lines showed no significant changes compared to the baseline data. However, for 5 of the 436 measurement lines, NextEra noted length changes that were unexpected. Further, NextEra noted that the gage points at CCI monitoring locations 1, 9, and 14 had moved out of range of the measurement instrument. NextEra plans to evaluate these locations further.

The team noted that the crack index data shows apparent increase when expansion data in 2-dimensions shows no change. It appears that the CI data better reflects expansion (strain) in the structure compared to the expansion measurements in only 2-dimensions, which may not be a complete indicator of changes in the structure. The team noted that NextEra plans to add deep pins to ASR impacted walls in the monitored locations that will allow expansion measurements in the third direction.

11.0 Review of Adequacy of Revisions to the Phase 3 Walkdown Plans and Schedule

Inspection Scope

During the previous inspection, the team reviewed the overall thoroughness of NextEra's completed and planned ASR walkdown activities conducted in accordance with FP 100642, "ASR Walkdown Scope," Revision 1, and documented in FP 100705, "Seabrook Station: Summary of Alkali Silica Reaction Walkdown Results," Revision 0. At the time of the inspection, not all of the potentially affected structures had been examined and NextEra had drafted a tentative schedule for the completion of the Phase 3 (areas not readily accessible) walkdowns. During this inspection, the team assessed NextEra's final Phase 3 schedule for completeness and to ensure a timely examination of the extent of condition of ASR-affected structures.

Findings and Observations

No findings were identified.

NextEra's ASR extent of condition structures walkdown is being conducted in three phases. Phase 1 involved examination of readily accessible areas of interest; Phase 2 included examination of coated surfaces identified during Phase 1 inspections (coatings had to be removed to expose the concrete surfaces); and Phase 3 examines normally inaccessible structures and areas (e.g. high radiation, manholes, etc.) which have or will be inspected at the earliest opportunity (e.g. routine maintenance or outage activities). Team examination of the Phase 3 walkdown areas identified a minor documentation issue (in addition to the previously documented containment IWL inspection oversight) that the spent fuel pool (SFP) reinforced concrete walls were not included in the planned Phase 3 walkdown. The SFP walls pose a particular challenge to NextEra due to the limited accessibility of the concrete surfaces. At the conclusion of this inspection, NextEra was working to complete their evaluation of various methods to assess the SFP concrete walls. A target date of June 30, 2013 was established to develop the necessary steps to accomplish this task (reference ASR Project Corrective Action Plan, revised April 2013). NextEra had already initiated plans to remove a core sample from the SFP telltale sump, per an earlier commitment made under the license renewal process (reference ____________).

The team assessed the Phase 3 walkdown schedule and concluded the target dates for completion were reasonable. With respect to completing a comprehensive examination of the containment structure, the team concluded that performing this inspection concurrent with the scheduled 2015 refueling outage IWL examination was appropriate and commensurate with the safety significance of the issue. The balance of the Phase 3 extent of condition walkdowns are scheduled for completion in mid-to-late 2013 and during the April 2014 refueling outage. In summary, the team concluded that NextEra's completed and planned extent of condition reviews for identification of ASR-affected reinforced concrete structures was appropriate.

12.0 Aircraft Impact Review

Inspection Scope

Comment [A12]: Recommend making the wording consistent with that in the commitment. The application portion was revised to state "Perform a confirmatory core bore and expose rebar in an area under the catch basin in spent fuel pool leakage sump."

I haven't verified if this is the same as saying the SFP telltale sump, but I still recommend using consistent language.

Comment [A13]: The commitment (Commitment No. 67) came in as part of their August 11, 2011 response. ML11227A023

FYI. The commitment states "Perform one shallow core bore in an area that was continuously wetted from borated water to be examined for concrete degradation and also expose rebar to detect any degradation such as loss of material."

The team reviewed NextEra's evaluation of the aircraft impact study performed in response to the identification of ASR. The aircraft impact study for Seabrook containment is described in UFSAR Section 3.8.1.3 and Appendix 2P. As noted in the Updated Final Safety Analysis Report (UFSAR), the postulated aircraft impact load is not combined with any other containment transient design loading. Further, the study assumes the impact area to be on the dome just above the spring line.

Findings and Observations

No findings were identified.

The effects of an aircraft impact were found not to be controlling for overall containment design considerations. Also, the analysis assumes that the enclosure building fails when struck by the aircraft and deforms until the aircraft contacts the containment structure. The containment enclosure building design and analysis is described in UFSAR Section 3.8.4. NextEra's evaluation states that ASR has only been identified in below grade elevations of the containment and containment enclosure buildings, where sufficient moisture has contributed to ASR progression. To date, no above grade (or vicinity of the anticipated aircraft impact area) evidence of ASR has been identified on containment. As discussed in Section 11, a detailed ASR inspection in conjunction with the IWL examination will be conducted in 2015. Accordingly, NextEra has concluded that the Seabrook aircraft impact study remains valid and unaffected, based upon engineering evaluations of other ASR-affected reinforced concrete structures completed, to date.

13.0 UT-Austin Ferguson Structural Engineering Laboratory Visits

Scope of Review

On two separate occasions, members of the team visited the UT-Austin testing facility to observe ongoing activities and inspect general facility quality assurance and control measures as implement per NextEra's regulatory obligations. The team noted that NextEra has contractual agreements with MPR Associates and the UT-Austin Ferguson Structural Engineering Laboratory to oversee and conduct, respectively, the ASR large scale testing program. The team toured the facility, including: main fabrication and testing areas with overhead crane lifting capabilities; outside exposed and protected (green house) specimen curing areas, with continuous or cyclic wetting and drying capability; aggregate and sand storage yard; and office and laboratory spaces for storage and use of calibration and test equipment, as well as, environmentally controlled storage units for a variety of mortar bar, prism, and concrete cylinder test specimens. The team examined the large block anchor bolt test specimens, including the control specimen block which had been tested. The team also witnessed fabrication of the second large shear and lap-splice test beam, and some testing of cylinders for compressive strength and Modulus of Elasticity determination.

Findings and Observations

No findings were identified. The team verified appropriate oversight and quality control practices being implemented. Direct oversight by both UT-Austin supervisory staff and MPR engineers was evident and effective.

14.0 Meetings, Including Exit

On June 27, 2013, the team conducted an exit meeting to discuss the preliminary findings and observations with Mr. Kevin Walsh, Site Vice President, and other members of Seabrook Station staff. The inspectors verified that no proprietary information was retained by the inspectors or documented in this report.

SUPPLEMENTAL INFORMATION

KEY POINTS OF CONTACT

Licensee Personnel
B. Brown, Design Engineering Manager
A. Chesno, Performance Improvement Manager
K. Chew, License Renewal Engineer
R. Cliché, License Renewal Project Manager
M. Collins, Design Engineering Manager
J. Connolly, Site Engineering Director
R. Noble, Project Manager
M. O'Keefe, Licensing Manager
T. Vassallo, Principal Design Engineer
K. Walsh, Site Vice President
P. Willoughby, Licensing Engineer

LIST OF ITEMS OPENED, CLOSED, DISCUSSED, AND UPDATED

Updated
None

Opened
None

Closed
None

LIST OF DOCUMENTS REVIEWED

Procedures
Maintenance Rule Scoping Document, Revision 0
EDS 36180, Structures Monitoring Program, Revision 0, 1, 2

Corrective Action Documents (AR)
1651969, 1629504, 574120, 581434, 1636419, 1673102, 1647722, 1664399, 1677340, 1687932, 1692374, 1698739, 1755727, 1757861, 1819080, 1804477, 1819069

Drawings

Licensing and Design Basis Documents and Calculations
Seabrook Station UFSAR, Revision 14
ACI 318-71
Calculation CD-20
Calculation CD-18
Calculation C-S-1-10168

Miscellaneous Documents
FP 100348, Statistical Analysis-Concrete Compression Test Data (PTL)
FP 100642, Scope for Alkali-Silica Reaction Walkdowns
FP 100641, Procedure for ASR Walkdowns and Assessment Checklist
FP 100661, Compression Testing Concrete Cores (WJE)
FP 100696, Material Properties of ASR-Affected Concrete
FP 100700, Field Investigation
FP 100705, Structure ASR Walkdown Report (MPR 0326-0058-58)
FP 100714, Three Dimensional Dynamic Analysis of Containment Enclosure Building
FP 100715, ASR Impact Study on Containment Enclosure Building
FP 100716, Interim Assessment: Impact of ASR on Structures (MPR-3727)
FP 100717, ACI 318-71 Perspectives
FP 100718, Anchor Test Report (MPR-3722)
FP 100720, Crack Index and Expansion Measurement
FP 100738, Measurements for ASR Crack Indexing on Concrete Structures
FP 100697, MPR 0326-0058-53, White Paper on Structural Implications of ASR: State of the Art, Revision 1
MPR 0326-0058-83, Shear Screening Criteria Used in MPR-3727
FHWA-HIF-09-004, Federal Highway Administration, "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction in Transportation Structures."

Documents Reviewed at FSEL

1. Purchase Order No. 0326 – 0058 -25, dated December 1, 2011 and change order Nos. 1, dated March 21, 2012; No. 2, dated March 27, 2012; No. 3, dated July 23, 2012; and No. 4, August 2, 2012 between MPR Associates Inc. and Ferguson Structural Engineering Laboratory as applied to Anchor Testing Program

2. Contract No. 02293285, dated June 6, 2011, and Amendment Nos. 1, dated October 25, 2011; No. 2, dated December 17, 2011; No. 003, dated January 3, 2012; No. 004, dated February 27, 2012; Amendment 6, dated July 26, 2012, between NextEra and MPR Associates Inc.

3. MPR Letter to Ferguson Structural Engineering Laboratory, dated December 1, 2011, Notice of Intent to Contract for Testing of Anchors in ASR-affected Concreter – authorizing FSEL to develop project-specific quality system manual, implementing procedures for testing and perform initial characterization of the ASR degradation on girders.

4. MPR Letter to Ferguson Structural Engineering Laboratory, dated December 1, 2011, Research on Performance of Anchors in ASR-affected Concrete

5. MPR Letter to Ferguson Structural Engineering Laboratory, dated March 27, 2012, Research on Performance of Anchors in ASR-affected Concrete

6. MPR Letter to Ferguson Structural Engineering Laboratory, dated July 23, 2012, Research on Performance of Anchors in ASR-affected Concrete

7. MPR Letter to Ferguson Structural Engineering Laboratory, dated August 2, 2012, Research on Performance of Anchors in ASR-affected Concrete

8. MPR Letter to Ferguson Structural Engineering Laboratory, dated October 26, 2012, Research on Performance of Anchors in ASR-affected Concrete

9. Purchase Order No. 0326 – 0063 -01, dated June 4, 2012, between MPR Associates Inc. and Ferguson Structural Engineering Laboratory as applied to Beam Testing Program

10. Contract No. 02207204, dated April 27, 2012, NextEra and MPR Associates Inc., related to ASR Concrete Beam Testing Program (for Shear and Lap-splice anchorage)

11. Project Plan 0326 – 0062 -01, Revision 0, dated May 1, 2012, by MPR Associates Inc. as applied to Beam Testing Program

LIST OF ACRONYMS

ACI	American Concrete Institute
ADAMS	Agencywide Documents Access and Management System
AMP	Aging Management Program
AR	Action Request
ASME	American Society of Mechanical Engineers
ASR	Alkali-Silica Reaction
BRE	Building Research Establishment
CAL	Confirmatory Action Letter
CCI	Combined Crack Index
CEB	Containment Enclosure Building
CFR	Code of Federal Regulations
CW	Circulating Water
DCR	Demand to Capacity Ratios
DGB	Diesel Generator Building
DRI	Damage Rating Index
DRP	Division of Reactor Projects
DRS	Division of Reactor Safety
EDG	Emergency Diesel Generator
EFW	Emergency Feedwater
EPRI	Electric Power Research Institute
EOC	Extent-of-Condition
ET	Electric Tunnel
EV	Equipment Valve
FEA	Finite Element Analysis
FHWA	Federal Highway Administration
FP	Foreign Print
FPL	Florida Power and Light
FSEL	Franklin Structural Engineering Laboratory
IMC	Inspection Manual Chapter
IP	[NRC] Inspection Procedure
LF	Load Factor
MPR	MPR Associates, Inc.
NRC	Nuclear Regulatory Commission
PARS	Publicly Available Records
P&ID	Piping and Instrument Diagram
PM	Preventative Maintenance
POD	Prompt Operability Determination
PRA	Probabilistic Risk Assessment
psi	pounds per square inch
QA	Quality Assurance
RCA	Radiologically Controlled Areas
RCE	Root Cause Evaluation
RHR	Residual Heat Removal
SDP	Significance Determination Process
SG&H	Simpson, Gumpertz & Heger

SMP	Structures Monitoring Program
SRI	Senior Resident Inspector
UFSAR	Updated Final Safety Analysis Report
UT-A	University of Texas - Austin
UK	United Kingdom
WO	Work Orders

Marshall, Michael

From: Marshall, Michael
Sent: Thursday, August 01, 2013 11:04 AM
To: Cook, William; Trapp, James
Cc: Erickson, Alice; Buford, Angela
Subject: RE: Draft Seabrook ASR CAL Follow-up Report for your review
Attachments: IR 2012-010 draft 7-23-13 (RASB Comments).docx

Hello Bill and Jim,

Attached are RASB's comments on the second Seabrook ASR CAL inspection report. We only had minor comments, and we provided the ML number for a reference.

Best Regards,
Michael L. Marshall, Jr.
Chief
Aging Management of Structures, Electrical, and Systems Branch
Division of License Renewal
Office of Nuclear Reactor Regulation

301-415-2871
Email: michael.marshall@nrc.gov

From: Cook, William
Sent: Tuesday, July 23, 2013 5:28 PM
To: Trapp, James; Dentel, Glenn; Marshall, Michael; McMurtray, Anthony
Cc: Raymond, William; Cook, William; Buford, Angela; Floyd, Niklas
Subject: Draft Seabrook ASR CAL Follow-up Report for your review

Attached is the draft report for your early review and feedback. We would appreciate your review and comments at your earliest convenience.

Thanks,
Bill Cook

B140

Buford, Angela

From: Marshall, Michael
Sent: Friday, August 02, 2013 9:40 AM
To: Buford, Angela
Subject: RE: Draft Seabrook ASR CAL Follow-up Report for your review

Angie,

Yes, just curious. What did you think about our comments?

Michael
301-415-2871
Email: michael.marshall@nrc.gov

From: Buford, Angela
Sent: Thursday, August 01, 2013 11:40 AM
To: Marshall, Michael
Cc: Erickson, Alice; Cook, William; Trapp, James
Subject: RE: Draft Seabrook ASR CAL Follow-up Report for your review

Michael, FYI: I also provided comments/edits to Bill as part of the inspection team that weren't intended to represent RASB's comments. If you would like to see those, let me know.

Thanks,

Angie

From: Marshall, Michael
Sent: Thursday, August 01, 2013 10:04 AM
To: Cook, William; Trapp, James
Cc: Erickson, Alice; Buford, Angela
Subject: RE: Draft Seabrook ASR CAL Follow-up Report for your review

Hello Bill and Jim,

Attached are RASB's comments on the second Seabrook ASR CAL inspection report. We only had minor comments, and we provided the ML number for a reference.

Best Regards,
Michael L. Marshall, Jr.
Chief
Aging Management of Structures, Electrical, and Systems Branch
Division of License Renewal
Office of Nuclear Reactor Regulation

301-415-2871
Email: michael.marshall@nrc.gov

From: Cook, William
Sent: Tuesday, July 23, 2013 5:28 PM
To: Trapp, James; Dentel, Glenn; Marshall, Michael; McMurtray, Anthony

B(4)

Cc: Raymond, William; Cook, William; Buford, Angela; Floyd, Niklas
Subject: Draft Seabrook ASR CAL Follow-up Report for your review

Attached is the draft report for your early review and feedback. We would appreciate your review and comments at your earliest convenience.

Thanks,
Bill Cook

Marshall, Michael

From: Marshall, Michael
Sent: Friday, August 02, 2013 2:08 PM
To: Galloway, Melanie
Subject: ACTION: Seabrook ASR CAL Follow-up IRpt
Attachments: IR 2012-010 draft 8-01-13.docx

Hello Melanie,

Attached is an advanced copy of the second and final Seabrook ASR CAL inspection report that will be placed in concurrence next week for your review.

Michael L. Marshall, Jr.
Chief
Aging Management of Structures, Electrical, and Systems Branch
Division of License Renewal
Office of Nuclear Reactor Regulation

301-415-2871
Email: michael.marshall@nrc.gov

From: Cook, William
Sent: Friday, August 02, 2013 2:06 PM
To: Heater, Keith; Powell, Gerry; Cowan, Grace
Cc: Marshall, Michael; Buford, Angela; Trapp, James; Lorson, Raymond
Subject: Seabrook ASR CAL Follow-up IRpt

Inspection Report No. 05000443/2012010 is ready for final formatting and concurrence. The report has to be signed out by the end of next week. We would like to include Melanie Galloway's concurrence from the Division of License Renewal in NRR, if available. Melanie concurred on the previous report and it would be good to have her review and concurrence again. I discussed Melanie's concurrence with Michael Marshall this week. This report incorporates everyone's comments and edits, to date, except Ray Lorson's.

Thanks for your support.
Bill

Michael – please share this copy with Melanie if she would like to have it in advance of ADAMS availability.. Thanks.

The report is located at G:\drs\seabrook concrete\cal closure report 2012010

B142

Lamb, John

From: Dacus, Eugene(OCA
Sent: Tuesday, August 06, 2013 10:53 AM
To: Lamb, John
Subject: Seabrook Meeting

John

I'm hearing that the ASR meeting will be last week of September. What do you think?

Gene

Eugene Dacus
Sr. Congressional Affairs Officer
U.S. Nuclear Regulatory Commission
Office: 301-415-1697
Fax: 301-415-8571
E-mail: eugene.dacus@nrc.gov

B143

Marshall, Michael

From: Marshall, Michael
Sent: Wednesday, August 07, 2013 4:37 PM
To: Trapp, James
Cc: Cook, William
Subject: RE: Seabrook ASR Inspection Report

Jim,

I may have made a mistake. I told Melanie she was concurring. She was reading the report today, but I do not know if she finished. I have a meeting with her in the morning. At that meeting, I will ask her whether she is done. She is aware that Region 1 wants to issue on Friday.

Michael L. Marshall, Jr.
Chief
Aging Management of Structures, Electrical, and Systems Branch
Division of License Renewal
Office of Nuclear Reactor Regulation

301-415-2871
Email: michael.marshall@nrc.gov

From: Trapp, James
Sent: Wednesday, August 07, 2013 9:54 AM
To: Marshall, Michael; McMurtray, Anthony
Cc: Cook, William; Buford, Angela; Raymond, William
Subject: Seabrook ASR Inspection Report

Just wanted to let you know that we are planning to the Seabrook Report by this Friday. We are waiting on Ray Lorson's comments.

While you are not on concurrence, I know that you provided us valuable feedback that has been incorporated into the report.

Michael – during our last report, I remember your management had some significant improvements that we incorporated into the cover letter for the report. This report has the same paragraph included so I think we will be ok – but just wanted to confirm that your management is ok with us proceeding.

Again – really appreciate all the help! Thank you all.

B144

Buford, Angela

From: Buford, Angela
Sent: Thursday, August 08, 2013 2:09 PM
To: Trapp, James
Subject: See Page 10 for Technical Revision
Attachments: IR 2012-010 FINAL 8-01-13 Buford - Galloway Comments.docx

Jim,

We need to revise page 10 of the report, as it reads it doesn't correctly characterize what NextEra did to obtain additional margin for some structures.

B145

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
2100 RENAISSANCE BOULEVARD, SUITE 100
KING OF PRUSSIA, PENNSYLVANIA 19406-2713

Mr. Kevin Walsh
Site Vice President
Seabrook Nuclear Power Plant
NextEra Energy Seabrook, LLC
c/o Mr. Michael Ossing
P.O. Box 300
Seabrook, NH 03874

SUBJECT: SEABROOK STATION, UNIT NO. 1 - CONFIRMATORY ACTION LETTER FOLLOW-UP INSPECTION - NRC INSPECTION REPORT 05000443/2012010

Dear Mr. Walsh:

On June 27, 2013, the U. S. Nuclear Regulatory Commission (NRC) completed a team inspection at Seabrook Station, Unit No. 1. The enclosed inspection report documents the inspection results, which were discussed with you and other members of your staff.

The team inspection examined activities conducted under your license as they relate to safety and compliance with the Commission's rules and regulations and with the conditions of your license. Specifically, the team reviewed selected procedures and records, observed activities, and interviewed station personnel regarding the adequacy of NextEra's actions to address the impact of Alkali-Silica Reaction (ASR) on reinforced concrete structures. The team reviewed selected Confirmatory Action Letter (CAL) 1-2012-002 commitments for adequacy and closure.

The NRC determined that the eleven actions committed to in the CAL have been satisfactorily completed. The team independently verified that NextEra had appropriately assessed and determined that all ASR-affected structures remain operable. The team also confirmed that your root cause evaluation was thorough and identified appropriate corrective actions.

Many important corrective actions necessary to resolve this issue are currently in progress and related commitments are documented in your ASR Project Corrective Action Program. These actions include your planned two year test program of ASR-affected large scale concrete specimens at the University of Texas, Ferguson Structural Engineering Laboratory (FSEL). Therefore, while our review of the CAL items was completed during this inspection, the NRC will continue to provide oversight of both NextEra's testing program at the FSEL and onsite ASR-related activities. Our final decision regarding closure of the CAL will be provided to NextEra in future correspondence.

It should be noted that the inspection team results are based solely on Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 requirements. The NRC is currently in the process of conducting a separate review of the ASR issue as part of the license renewal process in accordance with 10 CFR Part 54. As such, certain aspects of the ASR issue discussed may also have applicability to the license renewal review and require additional consideration and information beyond that discussed in this report.

In accordance with 10 CFR 2.390 of the NRCs "Rules of Practice," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of the NRC's document system (ADAMS). ADAMS is accessible from the NRC website at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

Raymond K. Lorson, Director
Division of Reactor Safety

Docket No. 50-443
License No: NPF-86

Enclosures:
1. Inspection Report No. 05000443/2012010
   w/ Attachment: Supplemental Information
2. Confirmatory Action Letter 1-2012-002

cc w/encl: Distribution via ListServ

Enclosure

It should be noted that the inspection team results are based solely on Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 requirements. The NRC is currently in the process of conducting a separate review of the ASR issue as part of the license renewal process in accordance with 10 CFR Part 54. As such, certain aspects of the ASR issue discussed may also have applicability to the license renewal review and involve additional consideration and require additional information beyond that discussed in this report.

In accordance with 10 CFR 2.390 of the NRCs "Rules of Practice," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of the NRC's document system (ADAMS). ADAMS is accessible from the NRC website at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

Raymond K. Lorson, Director
Division of Reactor Safety
Docket No. 50-443
License No: NPF-86

Enclosures:
1. Inspection Report No. 05000443/2012010
   w/ Attachment: Supplemental Information
2. Confirmatory Action Letter 1-2012-002

cc w/encl: Distribution via ListServ

Distribution w/encl:
W. Dean, RA
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DOCUMENT NAME: G:\DRS\Seabrook Concrete\CAL Closure Report 2012010\IR 2012-010 FINAL 8-01-13.docx
ADAMS Accession No.: ML

☑ **SUNSI Review**		☑ **Non-Sensitive** ☐ Sensitive		☑ **Publicly Available** ☐ Non-Publicly Available
OFFICE	RI/DRS	RI/DRP	RI/DRS	RI/DRS
NAME	WCook	GDentel	JTrapp/	RLorson/
DATE	08/ /13	08/ /13	08/ /13	08/ /2013

OFFICIAL RECORD COPY

U.S. NUCLEAR REGULATORY COMMISSION

REGION I

Docket No.:	50-443
License No.:	NPF-86
Report No.:	05000443/2012010
Licensee:	NextEra Energy Seabrook, LLC
Facility:	Seabrook Station, Unit No. 1
Location:	Seabrook, New Hampshire 03874
Dates:	November 3, 2012 to June 270, 2013
Inspectors:	W. Cook, Team Leader, Division of Reactor Safety (DRS) S. Chaudhary, Reactor Inspector, DRS W. Raymond, Senior Resident Inspector A. Buford, Structural Engineer, Division of License Renewal (DLR), Office of Nuclear Reactor Regulation (NRR) G. Thomas, Structural Engineer, Division of Engineering, NRR A. Sheikh, Senior Structural Engineer, DLR, NRR N. Floyd, Reactor Inspector, DRS
Approved by:	James Trapp, Chief, Engineering Branch 1 Division of Reactor Safety

SUMMARY OF FINDINGS

IR 05000443/2012010; 11/03/2012 - 06/27/2013; Seabrook Station, Unit No. 1; Confirmatory Action Letter (CAL) Follow-up Inspection Report.

This report covered several weeks of onsite inspection at Seabrook Station, two weeks of inspection at the Ferguson Structural Engineering Laboratory (FSEL) University of Texas – Austin, and periodic in-office reviews, over the past eight months, by region-based inspectors and headquarters reviewers to assess the adequacy of NextEra's actions to address the impact of Alkali-Silica Reaction (ASR) on reinforced concrete structures at Seabrook Station. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process," Revision 4, dated December 2006.

Cornerstone: Mitigating Systems

During this second CAL follow-up inspection, the team examined the remaining six commitments documented in CAL No. 1-2012-002, dated May 16, 2012. The CAL items reviewed and closed during this inspection were 2, 4, 7, 8, 9 and 11. In addition, a number of observations documented in the first CAL follow-up inspection (NRC Inspection Report 05000443/2012009, Section 9.0) were reviewed and closed in this report. Closure of CAL Item 7 was administrative. NextEra had withdrawn commitment 7 by letter dated December 13, 2012 (ML12362A323) and the NRC reviewed and approved the change. NextEra's revision to this commitment was approved by the NRC as documented in the CAL revision letter, dated January 14, 2013 (ML13014A555).

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The review and closure of each CAL item signifies the NRC's satisfactory assessment of NextEra's commitments and planned corrective actions to address the ASR non-conforming condition at Seabrook Station. However, the completion of the CAL follow-up inspections does not represent the completion of NRC review and oversight of NextEra's actions to address the ASR issue. As discussed in the team's review of CAL Item 4 and the revised ASR Project Corrective Action Plan (CAP), NextEra has implemented a number of ongoing activities, in addition to the FSEL testing program, to address ASR-affected structures. The details of the NRC's plans to oversee these ongoing activities will be addressed separately.

NextEra's root cause evaluation (CAL Item 2) appropriately identified the significant causal and contributing factors resulting in ASR impacting reinforced concrete structures at Seabrook Station. NextEra's ASR Project CAP (CAL Item 4), provided in a letter to the NRC (ML13151A328), sufficiently captures the numerous corrective actions taken and planned to address the ASR non-conforming condition, and will remain in place to track the resolution of ASR at Seabrook Station.

The Mortar Bar Testing (CAL Item 6, reference NRC Inspection Report 05000443/2012009) was successfully completed, and the results indicated sufficient reactive silica and alkali in the Seabrook structures to fuel the progression of ASR for the foreseeable future. Consequently, NextEra withdrew their commitment for Prism Testing (CAL Item 7) and the NRC staff administratively closed this commitment. The team reviewed NextEra's large specimen testing program technical specifications (CAL Item 8) and anchor testing program description (CAL Item 11) and concluded that these programs were sufficiently developed and described to support an appropriate understanding of the testing plans and objectives.

NextEra implemented a number of enhancements to the Structures Monitoring Program (CAL Item 9) to adequately monitor the progression of ASR. The team concluded these monitoring actions were consistent with currently available industry practices.

Lastly, the team completed a follow-up and review of a number of observations discussed in the first CAL Follow-up Inspection, including: 13 pending structural evaluations; containment prompt operability determination (POD) observations; core sample material property testing; quantification of pre-stressing effects of ASR expansion; additional rebar examinations; crack indexing use in the SMP; and the Phase 3 walkdown plans and schedule.

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REPORT DETAILS

1.0 Background

Alkali-Silica Reaction (ASR) is a chemical reaction occurring in hardened concrete that can change the physical properties of concrete and affect structural performance. In June 2009, NextEra identified potential degradation in below-grade concrete structures at Seabrook. In August 2010, NextEra completed petrographic evaluation of concrete core samples, which confirmed ASR as the degradation mechanism. The degraded condition in numerous Seabrook Category I structures was evaluated in the Corrective Action Program via prompt operability determinations (PODs). NextEra revised the PODs as new information became available and improved analytical techniques were incorporated.

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NextEra initially used the results of mechanical testing of concrete core samples to assess the degree of structural degradation due to ASR. This is a traditional method described in American Concrete Institute (ACI) 228.1R, "In-Place Methods to Estimate Concrete Strength," for assessing existing concrete structures. NextEra tested the cores for compressive strength and elastic modulus. NextEra used the methods defined in construction and design code ACI 318-1971, "Building Code Requirements for Reinforced Concrete," to evaluate the structural capacity (operability) of the ASR-affected structures. However, the mathematical relationships in ACI-318 are based on empirical data from testing of non-degraded concrete, and these relationships may not be valid for ASR-affected concrete.

After further review of industry experience and literature pertaining to ASR, NextEra engineering concluded that the core test data was not indicative of structural performance of ASR-affected reinforced concrete structures. NextEra's engineering evaluation stated that once the cores are removed from the structure, concrete core samples are no longer subject to the strains imposed by the ASR-related expansion or restraints imposed by the steel reinforcing cage. The engineering evaluation also stated that confinement provided by steel reinforcing bars (rebar) and other restraints limit ASR expansion of the concrete within the structure and thereby limit the adverse impact on structural performance. Therefore NextEra engineering concluded that the reduction of mechanical properties observed in mechanical testing of cores was not representative of in-situ concrete performance. Based on this conclusion, NextEra suspended taking core samples to evaluate the concrete mechanical properties of structures impacted by ASR and revised the operability assessment approach. NextEra's current approach for assessing structural integrity and operability is to compare available design margins to an assumed reduction in structural capacity due to ASR.

NextEra's operability evaluations were based upon an examination of available design margins and a presumed ASR-caused reduction in structural design capacities. The details of this methodology and related assumptions were developed in NextEra's Interim Assessment (FP 100716). The assessment assumed lower bound values of structural capacity for ASR-affected concrete for limit states based on research test data, primarily from small scale test specimens. The assessment focused on the structural limit states that are the most sensitive to ASR effects (i.e., out-of-plane shear capacity, lap splice development length, and anchorage capacity). The assessment determined that even after applying lower-bound values to structural limit states to assume ASR effects, the structures were suitable for continued service. A final operability assessment will be conducted by NextEra following evaluation of structural performance based on a proposed large scale testing program of beam specimens representative of Seabrook reinforced concrete structures. The test program has been initiated at the Ferguson Structural Engineering Laboratory at the University of Texas at Austin (UT-A), with some testing (anchors) commenced in 2013 and large beam testing scheduled to be completed by 2015. Based upon the slow progression of the ASR expansion, the current operability evaluations, coupled with the Structures Monitoring Program six-month combined crack indexing, provide reasonable assurance of continued structural operability.

2.0 Confirmatory Action Letter 1-2012-002

Confirmatory Action Letter 1-2012-002, dated May 16, 2012, was written to confirm commitments by NextEra (established during a meeting with NRC management and staff on April 23, 2012) with regard to planned actions to evaluate ASR-affected reinforced concrete structures at Seabrook Station. In response to the CAL, NextEra committed to provide information to the NRC staff to assess the adequacy of NextEra's corrective actions to address this significant condition adverse to quality. CAL 1-2012-002 is provided as an Enclosure to this report. The NRC staff also formed a working group to provide appropriate oversight of NextEra's activities to address ASR and to coordinate NRC inspection and review activities. The ASR Working Group Charter (ML121250588) outlines the regulatory framework and general acceptance criterion for NRC oversight and review of this issue. As documented in NRC Inspection Report No. 05000443/2012009, dated December 3, 2012 (ML12338A283) CAL Items 1, 3, 5, 6, and 10 were closed. Based on the results of this inspection, the remaining six CAL Items 2, 4, 7, 8, 9, and 11 are closed.

3.0 Review of Alkali-Silica Reaction Root Cause Evaluation (CAL Item 2)

<u>Inspection Scope</u>

As documented in Inspection Report No. 05000443/2012009, the team reviewed NextEra's response to CAL Item 2, "Submit the root cause for the organizational causes associated with the occurrence of ASR at Seabrook Station and related corrective actions by May 25, 2012."

The licensee submitted their root cause evaluation (RCE) in a letter to the NRC dated May 24, 2012 (ML12151A396). Based upon the team's initial review, the inspectors concluded that the second root cause identified was not sufficiently characterized in NextEra's May 24, 2012, submittal. Specifically, NextEra did not clearly describe the personnel and organizational factors that contributed to inadequacies in the Structures Monitoring Program (SMP) and the failure of the Seabrook staff to have identified ASR degradation of reinforced concrete structures sooner. The team discussed this observation with the responsible Seabrook staff. NextEra determined that a revision to the RCE was warranted and revised the RCE to more appropriately develop and characterize this second root cause and the associated corrective actions.

NextEra submitted a revised RCE summary for NRC review in a letter dated May 1, 2013 (ML13151A328, Enclosure 1). The team reviewed the revised RCE summary for clarity and appropriateness of associated corrective actions, consistent with guidance outlined in 10CFR50, Appendix B, Criterion XVI, "Corrective Action," and NextEra's Corrective Action Program (CAP).

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Findings and Observations

The team identified no findings. Based upon the team's review, CAL Item 2 is closed.

As documented in Enclosure 1 to the May 1, 2013 letter, NextEra summarized the two root causes as follows: RC1 – the ASR developed because the concrete mix design unknowingly utilized a coarse aggregate that would, in the long-term, contribute to ASR. Although the testing was conducted in accordance with American Society for Testing and Materials (ASTM) standards, those testing standards were subsequently identified as limited in their ability to predict slow reacting aggregate that produced ASR in the long-term; and RC2 – based on the long-standing organizational belief that ASR was not a credible failure mode due to the concrete mix design, dispositions for condition reports involving groundwater intrusion or concrete degradation, along with the structures health monitoring program, did not consider the possibility of ASR development. In addition, NextEra identified a contributing cause that their organization did not prioritize groundwater elimination or mitigation, resulting in more concrete area exposed to moisture.

The team verified that NextEra had appropriately identified the root cause(s). The ASTM concrete aggregate testing standards in effect at the time of plant construction were properly implemented, but later determined to be ineffective in identifying slow-reacting, ASR-susceptible aggregates. Those standards were subsequently revised by the industry and adopted by NextEra to prevent recurrence. NextEra's RCE concluded that the Structures Monitoring Program (SMP) did not remain current with concrete industry operating experience and associated failure modes, such as ASR. Contributing to the shortcomings of the SMP in not identifying this concrete degradation mechanism earlier was the "organizational mindset" that the groundwater in-leakage was an operational nuisance and nothing more. Consequently, station and engineering staffs were insensitive to the potential detrimental effects of the groundwater infiltration and did not assess the long-term impact on station structures. The team concluded that NextEra's implementation of a broad periodic review process to ensure all systems and component monitoring programs remain current and effective was determined an appropriate corrective action for this causal factor.

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4.0 Integrated Corrective Action Plan (CAL Item 4)

Inspection Scope

CAL No. 1-2012-002 documented NextEra's commitment to submit, by June 8, 2012, a corrective action plan for the continued assessment of ASR in concrete structures at Seabrook Station, including development of remedial actions to mitigate the effects of ASR where warranted. By letter dated June 8, 2012 (ML12171A227), NextEra submitted their integrated corrective action plan (CAP) for NRC review. The CAP outlined the major elements of diagnosis, evaluation, prognosis and mitigation of ASR-affected structures as understood at the time. Since June 8, 2012, NextEra has made considerable progress in refining the elements of this plan, implementing the initial phases, and more clearly defining and focusing future actions. NextEra provided an updated ASR Project CAP in a letter dated May 1, 2013 (ML13151A328, Enclosure 2) to document these plan changes.

During this inspection period, the team conducted numerous discussions, meetings, and conference calls with NextEra, as well as onsite inspections at both Seabrook Station and UT-Austin to review NextEra's actions to address the ASR-affected reinforced concrete structures. From these interactions, the CAP has developed greater clarity of the necessary steps (corrective actions) to address this non-conforming condition impacting safety-related reinforced concrete structures. As previously documented in Inspection Report 05000443/2012009 and detailed in other sections of this report, the team assessed the adequacy of completed and ongoing ASR-related activities identified in the integrated CAP, consistent with guidance outlined in 10CFR50, Appendix B, Criterion XVI, "Corrective Action," and NextEra's Quality Assurance Program.

Findings and Observations

The team identified no findings. Based upon the team's review, CAL Item 4 is closed. NextEra's ASR project staff stated that they plan to maintain the ASR Project CAP as a "living document" and will update it periodically to capture completion of activities and add new actions, as appropriate.

5.0 Prism Testing Commitment Withdrawn (CAL Item 7)

Inspection Scope

CAL Item 7 committed NextEra to "Complete long-term aggregate expansion testing (ASTM C 1293, Concrete Prism Test) by June 30, 2013." The purpose of this CAL item was to determine, in conjunction with the Mortar Bar Testing (CAL Item 6), if the coarse aggregate contributing to ASR in Seabrook reinforced concrete still contained sufficient reactive silica for the alkali-silica reaction to continue long-term under the existing environmental conditions. Alternatively, these tests could demonstrate that the progression of ASR at Seabrook could be self-limiting due to the depletion of reactive silica in the concrete. The Prism Test (as defined by ASTM C1293) involves monitoring the expansion (by measurement of specimen elongation due to ASR) of the test specimen (a molded concrete brick approximately 3 by 5 by 12 inches in length) over a one year period. Expansion in excess of 0.04% is considered potentially deleterious and a positive test for slow-reactive aggregate. The Prism Test is similar to the Mortar Bar Test (reference ASTM C1260), but has a duration of 14 days and an expansion limit of 0.1%.

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Based upon the results of the completed Mortar Bar Expansion Testing (reference NRC Inspection Report No. 05000443/2012009, Section 5.0), NextEra concluded that the available quantities of silica in the concrete would not be depleted in the near term and that additional confirmatory testing via the Prism Test method was not warranted. NextEra ran the Mortar Bar Test several weeks beyond the 14-day test (terminated after 103 days) and observed that the alkali-silica reaction was still progressing at the conclusion of the test, indicating the presence of sufficiently reactive aggregate to maintain ASR for a longer period of time. The team noted that the Mortar Bar Test involved the reuse of aggregates from Seabrook test cores (concrete that had already experienced appreciable ASR) and similar aggregate from concrete not affected by ASR. The side-by-side comparison of the test specimens showed no appreciable difference in ASR progression or observed expansion rates. Accordingly, NextEra concluded the Prism Test would add no significant knowledge to the condition assessment of Seabrook concrete. NextEra concluded that all Seabrook reinforced structures are or may be affected by ASR, unless specifically ruled out by further analysis, such as petrographic examination. By letter dated December 13, 2012, NextEra requested that CAL Item 7 be deleted. As documented in NRC letter dated January 14, 2013 (ML13014A555), the NRC accepted NextEra's technical basis for deleting CAL Item 7.

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Findings and Observations

No findings were identified. CAL Item 7 is administratively closed.

6.0 Review of Technical Details of Large Specimen Testing Program (CAL Item 8)

Inspection Scope

CAL Item 8 committed NextEra to "Submit the technical details of the testing planned at the contracted research and development facility by June 30, 2012." By letter dated June 21, 2012 (ML12179A281), NextEra submitted the Shear and Lap Splice Testing overview prepared by the Ferguson Structural Engineering Laboratory (FSEL) at the University of Texas at Austin, dated March 15, 2012. The purpose of the test program, as described in the FSEL document, is to provide sufficient data and insights to establish the current and future implications of ASR on Seabrook reinforced concrete structures. Since there is limited available literature or test data relative to the impact of ASR on walls without transverse shear reinforcements (i.e., the majority of Seabrook ASR-affected structures), destructive testing of ASR-affected test specimens is being conducted to evaluate the impact of ASR on out-of-plane shear strength and lap splice development. The test specimens being prepared at FSEL will be of representative scale and design such that the test results may be correlated to Seabrook structures.

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The team reviewed the June 21, 2012, submittal and conducted a conference call on December 18, 2012, with the NextEra and UT-Austin FSEL staff to discuss the merits of the proposed test program. Based upon the complexity of the information discussed and follow-up inspection activities, NextEra prepared a test program overview document and a detailed test specification to supplement the June 21, 2012, CAL response letter. By letter dated May 1, 2013 (ML13151A328 redacted and ML13151A291 un-redacted), NextEra provided the NRC with the "Seabrook Station - Specification for Shear and Reinforcement Anchorage Testing of ASR-Affected Reinforced Concrete," (Enclosures 3 & 4) and "Approach for Shear and Reinforcement Testing of Concrete Affected by Alkali Silica Reaction," (Enclosure 5 & 6). Each of these documents has a proprietary and non-proprietary version.

The team reviewed the revised testing specification and the associated overview document to verify that the overall test program approach and application of test results would reasonably address the Seabrook ASR-affected concrete non-conforming condition. The team discussed the test program with the FSEL, MPR and responsible NextEra engineering staffs.

Findings and Observations

No findings were identified. Based upon team review of the submitted testing program documents and related inspection activities, the team concluded that NextEra has provided a satisfactory explanation of the proposed large-scale specimen testing program, and CAL Item 8 is closed.

The team concluded that NextEra's approach has technical merit. However, as documented in NextEra's ASR Project CAP (ML 13151A328, Enclosure 2), the acceptance of the testing results to resolve ASR concerns associated with design basis structural calculations will follow the regulatory process for approval and will include evaluations pursuant to 10CFR50.59 and 10CFR50.90. As stated above, the submitted test plans satisfy NextEra's commitment to explain the scope and depth of the large-scale specimen testing program.

7.0 Review of Structures Monitoring Program (CAL Item 9)

Inspection Scope

CAL Item 9 committed NextEra to implement an update to the Maintenance Rule (10CFR50.65) Structures Monitoring Program (SMP) to include monitoring requirements for selected locations in areas that exhibit ASR by July 15, 2012. NextEra issued Revision 2 to Structural Engineering Standard 36180, "Structural Monitoring Program," effective July 12, 2012. The primary changes incorporated in Revision 2 to the SMP were: 1) performing periodic (every six months) crack indexing measurements at 26 locations to collect quantitative information on the progression of ASR expansion/degradation; 2) establishing crack width (1.0 mm or greater) and Combined Crack Index (1.0 mm/m or greater) thresholds for conducting structural evaluations (reference Foreign Print 100716, Seabrook Station: Impact of ASR on Concrete Structures and Attachments); and 3) the addition of Federal Highway Administration (FHWA) document FHWA-HIF-09-004, "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction in Transportation Structures," dated January 2010, as a reference.

The team reviewed the adequacy of these changes to the SMP to monitor ASR in Seabrook reinforced concrete structures. While not endorsed by the NRC or committed to by NextEra in Seabrook's licensing basis, the team used the American Concrete Institute (ACI) Committee Report 349.3R-96, "Evaluation of Existing Nuclear Safety-Related Concrete Structures," as a reference to assess the adequacy of the revisions made to the SMP for monitoring the progression of ASR.

Based in part on NRC observations, NextEra issued Revision 3 to the SMP on April 30, 2013. The SMP enhancements are: 1) the addition of periodic (every 30 months) combined crack indexing (CCI) measurements at 72 discrete locations identified as Tier II (Acceptable with Deficiency) areas (CCI values between 0.5 mm/m and 1.0 mm/m, or crack widths greater than 0.2 mm, but less than 1.0 mm) to collect quantitative information on the progression of ASR expansion/degradation (this monitoring was being performed, but not documented in the SMP); and, 2) inclusion of the periodic ground water sampling program for monitoring of chemical attributes detrimental to concrete structures. During a follow-up discussion with the NextEra staff, the team noted that NextEra is considering additional SMP revisions, dependent upon the results of the large specimen test program and further engineering evaluation. One of the revisions involves the installation of deep pins for monitoring of expansion in the out-of-plane direction (reference NextEra's May 1, 2013, Response to Confirmatory Action Letter (ML13151A328) Enclosure 2, ASR Project Corrective Action Plan).

Findings and Observations

The team identified no findings in this area. CAL Item 9 is closed.

The team noted that changes made to the SMP to address ASR were generally consistent with the evaluation and monitoring methods outlined in ACI 349.3R-96. The team confirmed that NextEra had incorporated a three-tiered visual inspection criteria, as outlined in Sections 5.1 through 5.3 of ACI 349.3R-96. NextEra has also augmented this visual inspection criteria with periodic (six-month and 30-month interval) CCI measurements and associated structural evaluation thresholds based upon direct measurement (CCI) results. The CCI monitoring, performed at 98 selected locations (including containment), was implemented by NextEra based upon this method being a readily measurable indicator of ASR-related progression and based, in part, upon endorsement by FHWA and outlined in FHWA-HIF-09-004.

The crack growth monitoring provides a visual indication of the progression of ASR within a reinforced concrete structure. The relative width and number of visible cracks may be correlated to the overall progression of ASR and may be used to evaluate ASR impact on structural performance. However, ASR cracking and crack propagation is closely associated with the specific reinforcement design and structural loading. Accordingly, the adequacy of CCI measurement as a long-term structures monitoring methodology for Seabrook structures is being further evaluated by NextEra as part of the UT-Austin FSEL testing program. The results of the UT-Austin testing program is intended to be used to validate this methodology for application at Seabrook.

The evaluation of infiltration water chemistry and groundwater monitoring: ACI 349.3R-96 discusses environmental monitoring and related effects of aggressive water chemistry, including the potential for leaching. Accordingly, NextEra has integrated the periodic monitoring of groundwater chemistry into the SMP (reference Revision 3, dated 4/30/2013, Attachment 4). NextEra plans to investigate the expansion of the water chemistry monitoring program (reference AR No. 1758920-40) to include periodic analysis of infiltrated water (i.e., water that has migrated through below grade reinforced concrete walls). The establishment of an initial baseline analysis and continued periodic monitoring could provide some relative trend data for further evaluation and follow-up actions, as appropriate.

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The team concluded that the implemented and planned SMP enhancements provide NextEra with an improved program to assess the extent and degree of ASR progression and to more thoroughly monitor the environmental factors contributing to ASR. NextEra's initial SMP revision (Revision 2) was adequate; however, the SMP Revision 3 enhancements include multiple activities that are better aligned with ACI 349.3R guidance.

8.0 Review of Anchor Testing Program (CAL Item 11)

Inspection Scope

The micro-cracking caused by ASR may adversely impact the structural capacity of anchors that support safety-related piping, cable trays and other components. NextEra's initial operability determinations were supported by anchor performance testing conducted on available ASR-degraded specimens previously fabricated at or obtained by FSEL, UT-Austin (reference FP 100718). As documented in Inspection Report 05000443/2012009, the initial testing demonstrated satisfactory performance of the anchors in ASR-affected concrete during the earlier stages of ASR progression. NextEra's evaluation also stated that the eventual reduction in capacity due to ASR was sufficiently offset by established anchor manufacturer's design margins (FP 100716). However, based upon the limitations of the testing performed (on ASR-affected test specimens of different composition and compressive strength than Seabrook reinforced concrete structures), NextEra planned to conduct additional testing. The planned testing involves anchors installed (both during specimen fabrication and post-fabrication) in ASR-affected test specimens that more closely replicate the reinforced concrete structures and anchor configurations at Seabrook.

By licensee letter dated December 13, 2012 (ML12362A323), NextEra requested a revision to CAL Item 11 to address a schedule challenge to the targeted anchor testing program completion date. NextEra also proposed redefining CAL Item 11 to be consistent with the wording of CAL Item 8, regarding large-scale specimen testing. Specifically, NextEra revised their commitment to read, "Submit technical details of the anchor test program planned at the contracted research and development facility by February 28, 2013." The original commitment read, "Complete anchor test program by December 31, 2012. Results will be available for NRC review approximately 30 days after testing is complete." Based upon unexpected specimen fabrication delays and the slow progression of accelerated ASR aging, NextEra identified that it would not be possible to complete the anchor testing per the original commitment date.

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The NRC accepted NextEra's revised commitment, as documented in NRC letter dated January 14, 2013 (ML13014A555).

The team reviewed the details and adequacy of NextEra's anchor testing program as outlined in the proprietary "Anchor Testing Program Overview," dated February 26, 2013. The anchor testing program overview and associated testing specifications were docketed for NRC review via NextEra letter dated February 28, 2013 (ML13088A218 redacted and ML13088A229 un-redacted, dated March 15, 2013). The technical overview document and accompanying specifications outline the major elements of the proposed anchor testing program, including the key attributes of the fabrication of the test specimens, monitoring of the specimens as accelerated ASR aging progresses, and the details of the testing of individual anchor bolt configurations.

Findings and Observations

The team identified no findings. Based upon the team's review, CAL Item 11 is closed. During the team's visits to the UT-Austin FSEL, the team observed the conditions and controls implemented for the aging of the test blocks and testing of concrete sample cylinders for compressive strength and modulus of elasticity. The team witnessed appropriate implementation of the testing procedures by FSEL staff and proper oversight of these activities by the MPR staff.

At the conclusion of this inspection, the desired level of ASR progression in the test blocks had not been achieved to conduct the first round of ASR-affected anchor testing. The team reviewed the results of the control specimen anchor testing completed in November 2012. The purpose of the control specimen testing was to establish a baseline to determine the potential reduction in anchor bolt capacity due to ASR. Review of the test data (reference MPR Memorandum DRN 0326-0058-163, dated June 18, 2013) identified that all anchor bolt test results were in agreement with calculated capacities, and an appropriate baseline had been established for comparison during future testing.

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9.0 Review of Previously Identified Issues of Interest

9.1 Structural Evaluations for 13 Locations

As documented in Inspection Report 05000443/2012009, NextEra identified 26 locations (including containment) as having patterned cracking with a CCI of greater than 1.0 mm/m. In accordance with the SMP, Revision 2, structures with a CCI of >1.0 mm/m require a structural evaluation. NextEra's Interim Assessment documented an engineering judgment that biased the performance of detailed structural evaluations to the 11 locations with a CCI > 1.5 mm/m. The locations with a CCI of between 1.0 and 1.5 mm/m (13 locations) were considered bounded by the 11 areas subjected to a detailed evaluation. The lack of a documented structural evaluation for the 13 locations with a CCI of between 1.0 and 1.5 mm/m was a minor performance deficiency which NextEra entered into the CAP (AR 1804477 and AR 1819080). During this inspection, the team reviewed Calculation C-S-10168, Revision 1, and FP 100716, "Seabrook Station: Impact of Alkali-Silica Reaction on Concrete Structures and Attachments," Revision 2, which incorporated the additional evaluations for the 13 locations.

The evaluation methodology included reviewing the original calculations that govern the design of the structures to determine the design parameters associated with the general area of ASR degradation. The structural member's load demand and capacity were then noted and the margin calculated for comparison against the potential reductions in load capacities caused by ASR. The assumed reductions in capacity were determined based on lower bound values established in industry literature. A summary of the evaluation results was provided in Table 3 of FP100716, Revision 2. For areas where design margins were insufficient to offset assumed lower bound reductions in capacity due to ASR, further review was performed to determine if analysis could show that there was additional margin. For each of these areas, the analysis either removed load factors that were applied to the demand loads in the original design basis calculations, or used the 28 day compressive strength (based on field cylinder compressive strength measurements) to obtain a higher allowable stress. The analysis is described in Calculation C-S-1-10168, Revision 1. The team found the approach of reducing load factors to establish more representative demand loads in order to demonstrate additional margin to assure structural integrity despite the assumed reduction in capacity acceptable for the current state of ASR degradation. However, NextEra plans to credit the load factors in the load demand calculation to establish full qualification per the Final Safety Evaluation Report (FSAR) licensing basis in the final operability determination, following completion of the testing program at UT-Austin.

Comment [A1]: I revised this section primarily based on a re-review of the referenced calculations and C-S-1-10168 and secondarily based on Melanie's comment. Let me know if you need explanation on the basis of the change. - Angie

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The team concluded that NextEra's initial approach to perform a bounding analysis for areas with CCI >1.5 mm/m was not conservative, because the design margins vary in each structural member of each reinforced concrete structure. Once the impact of the ASR degradation on structural capacities is determined from the UT-Austin FSEL test program, NextEra plans to review the design calculations for each ASR impacted area to assure margins remain acceptable. The team concluded that NextEra revised assessment appropriately completed the engineering evaluations for structures that were identified with CCI values that exceeded the 1.0 mm/m SMP evaluation threshold.

9.2 Review of Core Sample Material Property Testing

As documented in Inspection Report 05000443/2012009, Section 3.2.9, the NRC planned to reexamine the need of additional core sampling of Seabrook structures for the purpose of monitoring and assessing the condition of ASR-affected reinforced concrete. For the long term, NextEra has elected to evaluate structural performance (operability) of the Seabrook ASR-affected reinforced concrete structures by developing a testing program involving large specimens that are fabricated to closely replicate the Seabrook concrete and reinforcement design. NextEra has pursued this method, instead of conducting detailed material properties testing of core samples, based upon available laboratory testing and data that indicates that measurable material properties of removed cores do not, under all circumstances, accurately represent the "in situ" mechanical properties of the concrete. The reason for the difference is that prior to removal of the core sample, that concrete specimen was subjected to the specific structural compressive stresses (dead loads, live loads, and hydrostatic loads) and inherent restraint due to reinforcement bars. When removed from the structural member, that concrete specimen is wholly unrestrained. In addition, as identified in the associated core sampling standard (ASTM C42, "Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete"), core sample test results may be "...affected by many factors such as the strength level of the concrete, the in-place temperature and moisture histories, the degree of consolidation, batch-to-batch variability, the strength-gain characteristics of the concrete, the condition of the coring apparatus, and the care used in removing cores."

The team's review of this issue has identified two general approaches to gaining an informed understanding of the impact of ASR on reinforced concrete structures. One approach is that being taken by NextEra to assess the overall structural performance of an ASR-affected structural member, much like (but not the same) as the performance of a load test prescribed by ACI 318, "Building Code Requirements for Structural Concrete," Chapter 20, "Strength Evaluation of Existing Structures." Whereas, the alternative approach involves analytical evaluations using as an input the measureable steel and concrete material property values derived from samples from the affected structure, also recognized by ACI 318, Chapter 20. NextEra is challenged to appropriately correlate the FSEL test program results to the Seabrook structures. Accordingly, NextEra plans to take additional core samples from both the test specimens and the Seabrook structures to better correlate the large specimen test results using petrography and mechanical testing. The team viewed additional core sampling as a good initiative to better correlate FSEL test data to the plant structures.

9.3 Containment Prompt Operability Determination (POD) and Pre-stressing Effects of ASR

As discussed in Inspection Report 05000443/2012009, the team noted that the confinement provided by the steel reinforcement bar (rebar) cage restrains ASR expansion resulting in ASR-induced or "chemical" pre-stressing of affected structural members. The team observed that NextEra had provided a qualitative explanation of this condition in the Interim Assessment (FP 100716), and in the containment POD and structural evaluation (reference AR 1804477). The team had concluded that a quantitative evaluation of this condition may be warranted to address this aspect of the non-conforming ASR condition.

During this inspection, the team discussed the impact of ASR-induced pre-stressing on reinforced concrete structures with NextEra and reevaluated NextEra's assessment in AR 1804477. The effect of "chemical" pre-stressing is to both increase the compressive stresses in the concrete (within the rebar cage) and to increase the tensile stresses in the rebar, as long as the rebar cage restraint is sustained (i.e., the concrete remains anchored to the rebar). Similar to fabricated pre-stressed concrete structural members, the ultimate load carrying capacity of the reinforced member is not significantly changed by the ASR-induced pre-stress. Some studies have identified that the tensile stress in the reinforcing steel caused by the ASR expansion results in a corresponding compressive stress on the concrete that balances the added load and initially results in reduced deflections under load and a stiffer structural behavior. However, without the ability to quantify the effect and account for the chemical pre-stressing in engineering evaluations, the team concluded that even though the ASR-induced pre-stressing may result in some beneficial effects in terms of structural stiffness, this cannot and should not be credited for the purpose of structural evaluation. It is possible that more advanced ASR conditions could result in the steel reinforcement strain limits being exceeded that could compromise the overall structural performance.

The team noted that although the combined crack index (CCI) had been measured at three locations on the outside surface of containment, absent quantitative analyses, NextEra had not shown that the containment reinforcements were below yield. Further, the team noted that the current design code for containment does not allow containment reinforcement strains to be above yield. The Seabrook containment was designed to ASME Section III, 1975 edition and used allowable stress design methodology. This methodology does not allow for stresses to exceed the elastic limit. Specifically, "in order to keep the containment basically elastic under service load conditions and below the range of general yield under factored primary loads, the allowable stresses and strains in this subsection shall not be exceeded." This issue was discussed with NextEra representatives who stated actions would be taken (reference AR 1804477) to determine the effects of ASR relative to the containment design code requirements. As this issue has been documented in the Seabrook CAP with an open operability determination, resolution of the issue will be monitored via the ROP baseline inspection activities.

The team concluded there was no significant safety concern with containment reinforcement strain at this time because: (1) the containment is heavily reinforced and ASR is highly localized affecting a small percentage of containment area; (2) the concrete strain (crack index) measured at the surface may not reflect the condition of the reinforcement; and, (3) the integrated leak rate test in 2010 showed the containment returning to pre-existing conditions. As stated in NextEra's containment POD, primary containment is fully operable and capable of meeting all its design basis functions, with some reduced margin.

9.4 Assessment of the Need for Further Rebar Examinations

As documented in Inspection Report 05000443/2012009, Section 3.2.9, the NRC reviewed the potential for ASR having an adverse impact on rebar. NextEra and their engineering consultants had concluded that rebar is unaffected by ASR-degraded concrete unless the cover concrete is severely damaged and the rebar is exposed. They concluded that ample alkali remains in the concrete to maintain rebar passivity and to preclude a corrosive environment.

The team determined that NextEra's position was acceptable. Based upon the examination of a limited number of Seabrook rebar, and the review of available industry operating experience associated with concrete degradation mechanisms, the team concluded that at the current level of ASR there is no evidence to suggest that the reinforcing steel bars at Seabrook are corroding. In accordance with the Seabrook SMP and their referenced American Concrete Institute 349.3R-96, "Evaluation of Existing Nuclear Safety Related Concrete Structures," periodic visual inspections (signs of leaching, staining, spalling and pop outs) coupled with soil and groundwater testing for aggressive chemistry conditions (i.e., chlorides, sulfates and pH) provide appropriate monitoring and industry recommended detection methodology. Inspections conducted have not identified any iron oxide staining attributed to rebar corrosion on any ASR-affected concrete structures at Seabrook. Consequently, the team has concluded that no additional rebar examinations (i.e., removing the cover concrete to expose rebar for visual inspection) are currently warranted.

9.5 Use of Combined Crack Indexing for Structures Monitoring Program

As previously documented in Inspection Report 05000443/2012009, Section 6.0, the team planned to examine NextEra's basis for using Combined Crack Indexing (CCI) as the primary SMP method to monitor the progression of ASR in Seabrook structures. The team noted that the basis for NextEra's selection of CCI for monitoring, as endorsed by the FHWA, is that CCI provides a direct visual and measurable method for the detection and monitoring of ASR progression. Although the objective of NextEra's UT-Austin testing program is to establish and correlate the degree of ASR progression to overall structural performance, the interim use of the CCI method and the 6-month interval measurements taken, to date, provide reasonable assurance that the level of degradation due to ASR remains essentially the same and that the progression rate is low. As such, the bounding engineering calculations and associated prompt operability determinations remain valid.

Best available information concerning the impact of ASR on a structural member indicates that the formation of ASR gel within the concrete matrix, and subsequent absorption of more water by that gel, results in gel expansion that generates stresses within the concrete matrix. These expansion stresses are transferred to the concrete and relieved by cracking that is present in both the exterior cover concrete and inside the rebar cage. For structures that are not triaxially reinforced (this includes the majority of the walls at Seabrook Station that have no through-wall shear reinforcement), the potential exists for some undetected out-of-plane crack formation that could result in an adverse impact on structural performance. As documented in Section 6.0, the large-scale testing program is intended to provide additional insights to the overall performance of non-triaxially reinforced wall structures.

In support of the use of CCI, which is a two-dimensional concrete surface measurement, NextEra is developing plans to install deep pins in ASR-affected walls at Seabrook to better monitor ASR progression. The large scale test specimens fabricated at the UT-Austin facility include three-dimensional through-wall pin placements which will provide a more comprehensive measurement of the ASR expansion and associated impact on structural performance. NextEra plans to install similar deep pins at the site in order to better correlate the UT-Austin testing results and the two-dimensional CCI data to actual structural performance.

As stated above, within the confines of the reinforcement cage, the ASR expansion is restrained and some of the expansion stresses are transferred to the reinforcing bars. The added stresses are carried by the steel rebar until its yield strength is reached. As a result, within a reinforced concrete structure, the visible ASR patterned cracking will be smaller and finer since the rebar is carrying the load and providing restraint to the concrete. The amount of restraint provided by the rebar is dependent upon the type, size and design of the concrete section. More heavily reinforced structures would more readily resist ASR expansion and may depict a different level of CCI compared to a lightly or non-reinforced structure with a similar degree of ASR progression. The team concluded that the use of periodic CCI measurements to monitor ASR progression appears appropriate.

9.6 Planned Regulatory Actions

As discussed in Section 6.0 above, and in NextEra's ASR Project CAP, the crediting of the FSEL test results for demonstrating current and longer term operability of ASR-affected reinforced concrete structures will be evaluated by NextEra pursuant to 10CFR50.59 and 10CFR50.90 (license amendment request). The team concluded that this approach appears reasonable and consistent with existing regulatory processes. The team notes that CCI may become the principle method used by NextEra for monitoring the progression of ASR in affected structures. Pending the results of the FSEL testing program, NextEra may propose the use of this methodology for assessing current and future operability of ASR-affected structures.

10.0 Review of Six-Month Combined Crack Indexing Data

Inspection Scope

The team reviewed the periodic concrete expansion measurements and observed field measurements for ASR-impacted Seabrook structures. Specifically, the team examined the supporting documentation for the ASR Crack Index Report, dated March 18, 2013 (FP 100811), and the ASR Expansion Measurements Report, dated March 18, 2013 (FP100812). The team also conducted interviews and discussions with the responsible NextEra engineering staff. The team used 10CFR50, Appendix B, Criterion XVI, "Corrective Action," and Criterion XI, "Test Control," as the regulatory guidance to assess the adequacy of NextEra's actions to address ASR-affected reinforced concrete structures.

Findings and Observations

No findings were identified. Overall, the combined crack index (CCI) data show some evidence of continued ASR degradation, but the expansion data (pin-to-pin measurements) showed no significant changes. There was no change in the CCI data for the containment, but the Electric Tunnel and the Primary Auxiliary Building/Residual Heat Removal (PAB/RHR) vault both show an increasing trend in CCI value in the six months since June 2012. While this may be the result of seasonal affects, ASR degradation appears to be ongoing in some Seabrook structures as indicated by some minor incremental crack growth. Collectively, the CCI measurements indicate essentially no structural changes, and therefore no challenges to the conclusions in the current ASR-affected structures' prompt operability determinations. The team noted NextEra's plans to continue the 6-month CCI measurements to establish a stable trend in observable ASR expansion for each uniquely ASR-affected structure. Continued periodic measurements should eliminate the potential influence of seasonal ambient temperature changes from the trend results.

CCI Measurements

In the ASR Crack Index Report (FP100811), NextEra measured CCI values for 26 locations in the monitoring program and compared the results to the data taken in June 2012. The CCI data shows an apparent increase in most (18 of 26) of the monitored locations. NextEra identified that the CCIs measured in December 2012 appear larger than the CCI data measured in June 2012. NextEra concluded the apparent increase in CCI values was due to seasonal temperature variations because the concrete (in December) was significantly colder, which may cause the concrete to contract between the cracks, increasing the apparent crack widths.

The team noted that 3 of 7 monitored locations on the exterior of plant buildings (above grade and more susceptible to seasonal temperature and moisture variations), showed a decrease in CCI from June to December. Further, 15 of 18 areas showing an increase in crack index were areas monitored on interior buildings surfaces and/or below grade, and therefore less susceptible to seasonal temperature variations. In particular, the Electric Tunnel (areas 3b, 4, and 5) and the PAB/RHR Vault (areas 17, 18, 22, and 23) all show a CCI value increase of between 0.20 to 0.26 mm/m compared to June 2012. These interior, below-grade areas have been chronically wet from ground water infiltration. The team noted there was no change in the CCI values for the Containment Building (Location 14 - Mechanical Penetration MF102-01).

As reported by NextEra, uneven cracking (total crack width in one direction is much larger than in the other direction) and measured larger cracks were identified in the horizontal direction compared to the vertical. The team observed that, over the long-term, averaging the horizontal and vertical CCI values may be an adequate representation of overall changes due to ASR of the specific structural member. However, the practice of averaging the horizontal and vertical CCI values is different than outlined by available industry guidance (FHWA-HIF-09-004) that recognizes the influence of reinforcements on crack growth. Thus, reporting an averaged CCI vice directional CCI values separately could mask the expansion in a preferred direction and hamper the identification of a trend in the short term. NextEra acknowledged this team observation and initiated a Condition Report (CR 1758920-41) to evaluate this issue.

The team also noted that NextEra revised the method of calculating CCI in the recent 6-month measurement report (December 2012). The CCI measurement reporting method was changed to account for the use of rectangular grids to determine crack index, and thereby normalize index to the total number of lines in the both directions. In so doing, NextEra recalculated the CCI values for the December 2011 and June 2012 data to eliminate potential biasing errors. The team concluded that NextEra's more consistent use of a calculation method would aid the identification of apparent trends.

Structure Expansion Measurements

In the Expansion Measurement Report (FP100812), NextEra performed measurements between pins embedded in the surface of plant buildings at the 26 established CCI monitoring locations. The 26 monitored locations were selected from the 131 locations identified in the ASR Walkdown Report (reference FP100705) which exhibited the highest visible ASR-associated distress. NextEra noted a null result for expansion measurements between pins in most of the 26 monitored locations. Specifically, data recorded in most (436) measurement lines showed no significant changes compared to the baseline data. However, for 5 of the 436 measurement lines, NextEra noted length changes that were unexpected. Further, NextEra noted that the gage points at CCI monitoring locations 1, 9, and 14 had moved out of range of the measurement instrument. NextEra plans to evaluate these locations further.

The team noted that the crack index data shows an apparent increase when expansion data in 2-dimensions shows no change. It appears that the CCI data better reflects expansion in the structure compared to the expansion measurements in only two dimensions, which may not be a complete indicator of changes in the structure. The team noted that NextEra plans to add deep pins to ASR impacted walls in the monitored locations that will allow expansion measurements in the out-of-plane direction (reference CR 1758920-39).

11.0 Review of Adequacy of Revisions to the Phase 3 Walkdown Plans and Schedule

Inspection Scope

During the previous inspection, the team reviewed the overall thoroughness of NextEra's completed and planned ASR walkdown activities conducted in accordance with FP 100642, "ASR Walkdown Scope," Revision 1, and documented in FP 100705, "Seabrook Station: Summary of Alkali Silica Reaction Walkdown Results," Revision 0. At the time of the inspection, not all of the potentially affected structures had been examined and NextEra had drafted a tentative schedule for the completion of the Phase 3 (areas not readily accessible) walkdowns. During this inspection, the team assessed NextEra's final Phase 3 schedule for completeness and to ensure a timely examination of the extent of condition of ASR-affected structures.

Findings and Observations

No findings were identified.

NextEra's ASR extent of condition structures walkdown is being conducted in three phases. Phase 1 involved examination of readily accessible areas of interest; Phase 2 included examination of coated surfaces identified during Phase 1 inspections (coatings had to be removed to expose the concrete surfaces); and Phase 3 examines normally inaccessible structures and areas (e.g. high radiation, manholes, etc.) which have or will be inspected at the earliest opportunity (e.g. routine maintenance or outage activities). Team examination of the Phase 3 walkdown areas identified a minor documentation issue (in addition to the previously documented containment IWL inspection oversight) that the spent fuel pool (SFP) reinforced concrete walls were not included in the planned Phase 3 walkdown. The SFP walls pose a particular challenge to NextEra due to the limited accessibility of the concrete surfaces. At the conclusion of this inspection, NextEra was working to complete their evaluation of various methods to assess the SFP concrete walls (reference ASR Project Corrective Action Plan, revised April 2013). NextEra had already initiated plans to perform one shallow core bore in an area that was continuously wetted (SFP telltale sump) from borated water. This core will be examined for concrete degradation and to look for any degradation of rebar (reference ML 1227A023, Commitment No. 67).

The team assessed the Phase 3 walkdown schedule and concluded the target dates for completion were reasonable. With respect to completing a comprehensive examination of the containment structure, the team concluded that performing this inspection concurrent with the scheduled 2015 refueling outage IWL examination was appropriate and commensurate with the safety significance of the issue. The balance of the Phase 3 extent of condition walkdowns are scheduled for completion in mid-to-late 2013 and during the April 2014 refueling outage. In summary, the team concluded that NextEra's completed and planned extent of condition reviews for identification of ASR-affected reinforced concrete structures was appropriate.

12.0 Aircraft Impact Review

Inspection Scope

The team reviewed NextEra's evaluation of the aircraft impact study performed in response to the identification of ASR. The aircraft impact study for Seabrook containment is described in UFSAR Section 3.8.1.3 and Appendix 2P. As noted in the Updated Final Safety Analysis Report (UFSAR), the postulated aircraft impact load is not combined with any other containment transient design loading. Further, the study assumes the impact area to be on the dome just above the spring line.

Findings and Observations

No findings were identified.

The effects of an aircraft impact were found not to be controlling for overall containment design considerations. Also, the analysis assumes that the enclosure building fails when struck by the aircraft and deforms until the aircraft contacts the containment structure. The containment enclosure building design and analysis is described in UFSAR Section 3.8.4. NextEra's evaluation states that ASR has only been identified in below grade elevations of the containment and containment enclosure buildings, where sufficient moisture has contributed to ASR progression. To date, no above grade (or vicinity of the anticipated aircraft impact area) evidence of ASR has been identified on containment. As discussed in Section 11, a detailed ASR inspection in conjunction with the IWL examination will be conducted in 2015. Accordingly, NextEra has concluded that the Seabrook aircraft impact study remains valid and unaffected, based upon engineering evaluations of other ASR-affected reinforced concrete structures completed to date.

13.0 UT-Austin Ferguson Structural Engineering Laboratory Visits

Scope of Review

On two separate occasions, members of the team visited the UT-Austin testing facility to observe ongoing activities and inspect general facility quality assurance and control measures as implement per NextEra's regulatory obligations. The team noted that NextEra has contractual agreements with MPR Associates and the UT-Austin Ferguson Structural Engineering Laboratory to oversee and conduct, respectively, the ASR large scale testing program. The team toured the facility, including: main fabrication and testing areas with overhead crane lifting capabilities; outside exposed and protected (green house) specimen curing areas - with continuous or cyclic wetting and drying capability; aggregate and sand storage yard; and office and laboratory spaces for storage and use of calibration and test equipment, as well as, environmentally controlled storage units for a variety of mortar bar, prism, and concrete cylinder test specimens. The team examined the large block anchor bolt test specimens, including the control specimen block which had been tested. The team also witnessed fabrication of the second large shear and lap-splice test beam, and some testing of cylinders for compressive strength and Modulus of Elasticity determination.

Findings and Observations

No findings were identified. The team verified appropriate oversight and quality control practices being implemented. Direct oversight by both UT-Austin supervisory staff and MPR engineers was evident and effective.

14.0 Meetings, Including Exit

On June 27, 2013, the team conducted an exit meeting to discuss the preliminary findings and observations with Mr. Kevin Walsh, Site Vice President, and other members of Seabrook Station staff. The inspectors verified that no proprietary information was retained by the inspectors or documented in this report.

SUPPLEMENTAL INFORMATION

KEY POINTS OF CONTACT

Licensee Personnel
B. Brown, Design Engineering Manager
A. Chesno, Performance Improvement Manager
K. Chew, License Renewal Engineer
R. Cliché, License Renewal Project Manager
M. Collins, Design Engineering Manager
J. Connolly, Site Engineering Director
R. Noble, Project Manager
M. O'Keefe, Licensing Manager
T. Vassallo, Principal Design Engineer
M. Ossing, Licensing Manager
K. Walsh, Site Vice President
P. Willoughby, Licensing Engineer

LIST OF ITEMS OPENED, CLOSED, DISCUSSED, AND UPDATED

Updated
None

Opened
None

Closed
None

LIST OF DOCUMENTS REVIEWED

Procedures
Maintenance Rule Scoping Document, Revision 0
EDS 36180, Structures Monitoring Program, Revisions 1, 2, 3

Corrective Action Documents (AR)
1651969, 1629504, 574120, 581434, 1636419, 1673102, 1647722, 1664399, 1677340, 1687932, 1692374, 1698739, 1755727, 1757861, 1819080, 1804477, 1819069

Drawings

Licensing and Design Basis Documents and Calculations
Seabrook Station UFSAR, Revision 14
ACI 318-71
Calculation CD-20; Calculation CD-18; and Calculation C-S-1-10168

Miscellaneous Documents
FP 100348, Statistical Analysis-Concrete Compression Test Data (PTL)
FP 100642, Scope for Alkali-Silica Reaction Walkdowns
FP 100641, Procedure for ASR Walkdowns and Assessment Checklist
FP 100661, Compression Testing Concrete Cores (WJE)
FP 100696, Material Properties of ASR-Affected Concrete
FP 100700, Field Investigation
FP 100705, Structure ASR Walkdown Report (MPR 0326-0058-58)
FP 100714, Three Dimensional Dynamic Analysis of Containment Enclosure Building
FP 100715, ASR Impact Study on Containment Enclosure Building
FP 100716, Interim Assessment: Impact of ASR on Structures (MPR-3727)
FP 100717, ACI 318-71 Perspectives
FP 100718, Anchor Test Report (MPR-3722)
FP 100720, Crack Index and Expansion Measurement
FP 100738, Measurements for ASR Crack Indexing on Concrete Structures
FP 100697, MPR 0326-0058-53, White Paper on Structural Implications of ASR: State of the Art, Revision 1
MPR 0326-0058-83, Shear Screening Criteria Used in MPR-3727
FHWA-HIF-09-004, Federal Highway Administration, "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction in Transportation Structures."
ASME III, Division 2, 1975 Edition, Winter '77 Addenda

Documents Reviewed at FSEL

Purchase Order No. 0326 – 0058 -25, dated December 1, 2011 and change order Nos. 1, dated March 21, 2012; No. 2, dated March 27, 2012; No. 3, dated July 23, 2012; and No. 4, August 2, 2012 between MPR Associates Inc. and Ferguson Structural Engineering Laboratory as applied to Anchor Testing Program

Contract No. 02293285, dated June 6, 2011, and Amendment Nos. 1, dated October 25, 2011; No. 2, dated December 17, 2011; No. 003, dated January 3, 2012; No. 004, dated February 27, 2012; Amendment 6, dated July 26, 2012, between NextEra and MPR Associates Inc.

MPR Letter to Ferguson Structural Engineering Laboratory, dated December 1, 2011, Notice of Intent to Contract for Testing of Anchors in ASR-affected Concreter – authorizing FSEL to develop project-specific quality system manual, implementing procedures for testing and perform initial characterization of the ASR degradation on girders.

MPR Letter to Ferguson Structural Engineering Laboratory, dated December 1, 2011, Research on Performance of Anchors in ASR-affected Concrete

MPR Letter to Ferguson Structural Engineering Laboratory, dated March 27, 2012, Research on Performance of Anchors in ASR-affected Concrete

MPR Letter to Ferguson Structural Engineering Laboratory, dated July 23, 2012, Research on Performance of Anchors in ASR-affected Concrete

MPR Letter to Ferguson Structural Engineering Laboratory, dated August 2, 2012, Research on Performance of Anchors in ASR-affected Concrete

MPR Letter to Ferguson Structural Engineering Laboratory, dated October 26, 2012, Research on Performance of Anchors in ASR-affected Concrete

Purchase Order No. 0326 – 0063 -01, dated June 4, 2012, between MPR Associates Inc. and Ferguson Structural Engineering Laboratory as applied to Beam Testing Program

Contract No. 02207204, dated April 27, 2012, NextEra and MPR Associates Inc., related to ASR Concrete Beam Testing Program (for Shear and Lap-splice anchorage)

Project Plan 0326 – 0062 -01, Revision 0, dated May 1, 2012, by MPR Associates Inc. as applied to Beam Testing Program

LIST OF ACRONYMS

ACI	American Concrete Institute
ADAMS	Agencywide Documents Access and Management System
AMP	Aging Management Program
AR	Action Request
ASME	American Society of Mechanical Engineers
ASR	Alkali-Silica Reaction
ASTM	American Society for Testing and Materials
BRE	Building Research Establishment
CAL	Confirmatory Action Letter
CAP	Corrective Action Program
CCI	Combined Crack Index
CEB	Containment Enclosure Building
CFR	Code of Federal Regulations
CR	Condition Report
CW	Circulating Water
DCR	Demand to Capacity Ratios
DGB	Diesel Generator Building
DLR	Division of License Renewal
DRI	Damage Rating Index
DRP	Division of Reactor Projects
DRS	Division of Reactor Safety
EDG	Emergency Diesel Generator
EFW	Emergency Feedwater
EPRI	Electric Power Research Institute
EOC	Extent-of-Condition
ET	Electric Tunnel
EV	Equipment Valve
FEA	Finite Element Analysis
FHWA	Federal Highway Administration
FP	Foreign Print
FPL	Florida Power and Light
FSAR	Final Safety Analysis Report
FSEL	Franklin Structural Engineering Laboratory
IMC	Inspection Manual Chapter
IP	[NRC] Inspection Procedure
LF	Load Factor
MPR	MPR Associates, Inc.
NRC	Nuclear Regulatory Commission
NRR	Office of Nuclear Reactor Regulation

PARS	Publicly Available Records
P&ID	Piping and Instrument Diagram
PM	Preventative Maintenance
POD	Prompt Operability Determination
PRA	Probabilistic Risk Assessment
PSI	pounds per square inch
QA	Quality Assurance
RCA	Radiologically Controlled Areas
RCE	Root Cause Evaluation
RHR	Residual Heat Removal
SFP	Spent Fuel Pool
SDP	Significance Determination Process
SG&H	Simpson, Gumpertz & Heger
SMP	Structures Monitoring Program
SRI	Senior Resident Inspector
UFSAR	Updated Final Safety Analysis Report
UT-A	University of Texas - Austin
UK	United Kingdom
WO	Work Orders

Buford, Angela

From: Buford, Angela
Sent: Thursday, August 01, 2013 11:40 AM
To: Marshall, Michael
Cc: Erickson, Alice; Cook, William; Trapp, James
Subject: RE: Draft Seabrook ASR CAL Follow-up Report for your review

Michael, FYI: I also provided comments/edits to Bill as part of the inspection team that weren't intended to represent RASB's comments. If you would like to see those, let me know.

Thanks,

Angie

From: Marshall, Michael
Sent: Thursday, August 01, 2013 10:04 AM
To: Cook, William; Trapp, James
Cc: Erickson, Alice; Buford, Angela
Subject: RE: Draft Seabrook ASR CAL Follow-up Report for your review

Hello Bill and Jim,

Attached are RASB's comments on the second Seabrook ASR CAL inspection report. We only had minor comments, and we provided the ML number for a reference.

Best Regards,
Michael L. Marshall, Jr.
Chief
Aging Management of Structures, Electrical, and Systems Branch
Division of License Renewal
Office of Nuclear Reactor Regulation

301-415-2871
Email: michael.marshall@nrc.gov

From: Cook, William
Sent: Tuesday, July 23, 2013 5:28 PM
To: Trapp, James; Dentel, Glenn; Marshall, Michael; McMurtray, Anthony
Cc: Raymond, William; Cook, William; Buford, Angela; Floyd, Niklas
Subject: Draft Seabrook ASR CAL Follow-up Report for your review

Attached is the draft report for your early review and feedback. We would appreciate your review and comments at your earliest convenience.

Thanks,
Bill Cook

Marshall, Michael

From: Marshall, Michael
Sent: Tuesday, August 27, 2013 10:47 AM
To: Trapp, James
Cc: Cook, William; Rogers, Billy; Erickson, Alice; Buford, Angela
Subject: RE: Seabrook ASR

Hello Jim,

Alice, Angie, and I plan to participate in the call. We will be calling into the bridge from Byron station.

Michael

From: Trapp, James
Sent: Tuesday, August 27, 2013 6:49 AM
To: Marshall, Michael; McMurtray, Anthony
Cc: Cook, William; Rodriguez, Veronica
Subject: Seabrook ASR

I'm not sure you've heard but the testing program at the University of Texas FSEL is not going as planned. The anchor test beams are not exhibiting ASR as measured by the CCI as expected by NextEra. The beam/block appears to be splitting down the middle.

We have a call set up with NextEra tomorrow that you've been invited to. This is just to encourage your participation.

After the call, I would like to regroup and discuss your CAL closure recommendation. Thanks

B146