Seabrook SER Sections on Alkali-Silica Reaction

9/18/18

Open Item OI 3.0.3.2.18-1
SER Section 3.0.3.2.18 — Structures Monitoring Program

Based on the operating experience related to concrete degradation due to alkali-silica reaction (ASR) discovered in 2010, the staff was concerned that the applicant had not enhanced the Structures Monitoring Program to manage the effects of ASR. This issue was identified as Open Item OI 3.0.3.2.18-1.

By letter dated May 18, 2018, the applicant submitted enhancements to the Structures Monitoring Program, revised Commitments No. 32, 33, and 67, and submitted enhancements to the ASME Section XI, Subsection IWL aging management program, to manage the effects of aging of concrete affected by ASR. The applicant also added two new plant-specific aging management programs, Alkali-Silica Reaction (ASR) Monitoring Program and Building Deformation Monitoring Program that augment the Structures Monitoring and Subsection IWL AMPs to manage the effects of aging of concrete affected by ASR. The applicant also added Commitments 45, 66, 83, and 91 related to these plant-specific AMPs. Based on the staff evaluation of these plant-specific AMPs documented in SER Sections 3.0.3.3.6 and 3.0.3.3.7, the staff's concern regarding the management of the effects of aging in concrete affected by ASR is resolved. Open item OI 3.3.2.18-1 is closed.

3.0.3.1.9 ASME Code Section XI, Subsection IWL Aging Management Program

Summary of Technical Information in the Application. LRA Section B.2.1.28, as revised through various LRA supplements and applicant's letters described below, discusses the existing ASME Section XI, Subsection IWL AMP as consistent, with enhancements, with GALL Report, Revision 1, AMP XI.S2, "ASME Section XI, Subsection IWL." The LRA states that all accessible reinforced concrete containment components are within the scope of this program. The LRA also states that the program complies with the examination requirements and acceptance criteria of ASME B&PV Code, Section XI, Subsection IWL, "Requirements for Class CC Concrete Components of Light-Water Cooled Power Plants," 1995 Edition with 1996 Addenda, as incorporated by reference in 10 CFR 50.55a. The LRA further states that this program manages the effects of aging for "loss of bond, loss of material (spalling, scaling) due to corrosion of embedded steel, expansion and cracking due to reaction with aggregates, increase in porosity and permeability, cracking, loss of material (spalling, scaling) due to aggressive chemical attack, and increase in porosity and permeability, loss of strength due to leaching of calcium hydroxide" on the reinforced concrete containment building.

The LRA states that testing and evaluation of concrete degradation due to aggressive chemical attack will be performed and corrective actions will be taken. In addition, the LRA states that the applicant will evaluate the acceptability of concrete in inaccessible areas of the containment consistent with the regulatory requirements of 10 CFR 50.55a(b)(2)(viii), when conditions exist in accessible areas that could indicate the presence of or result in degradation to such inaccessible areas.

Updates to the program description

By letters dated December 10, 2010, May 15, 2014, and February 28, 2018 (ADAMS Accession Nos. ML103540534, ML14142A220, and ML18075A391) the applicant revised LRA Section B.2.1.28 program description incorporating program changes to include information on:

- Integration of ACI-349.3R acceptance criteria for degraded concrete evaluation
- Definition of degradation due to ASR on concrete surface areas as:
    - Acceptable (i.e., No ASR; defines Tier 1, as described in letter dated May 15, 2014);
    - Acceptable with deficiencies and for further review (Combined Cracking Index (CCI) of less than 1.0 mm/m or Individual Crack Width of less than 1.0 mm; defines Tier 2);

    - Unacceptable requiring further evaluation (CCI of 1.0 mm/m or greater, or an Individual Crack Width of 1.0 mm or greater; defines Tier 3);

- Procedures for performing the VT1-C and VT3-C as general and detailed visual examinations of the concrete surfaces of the primary containment in accordance with requirements of ASME Code Section XI, Subsection IWL, 2004 Edition and no Addenda (in effect since August 19, 2010);
- Procedures to identify areas and types of concrete deterioration and distress, as described in ACI 201.1 and ACI 349.3R; and
- Integration of the ASME Code Section XI, Subsection IWL Program with the Structures Monitoring Program to monitor, trend, and evaluate observed indications of ASR; and compare results of new examinations against baseline examinations and prior inservice (ISI) results.

Summary of Staff Evaluation. The staff reviewed the program elements of the ASME Section XI, Subsection IWL AMP and found them consistent with the corresponding program elements of GALL Report AMP XI.S2. However, based on the cracking due to expansion from reaction with aggregates, or ASR, degradation mechanism affecting concrete at Seabrook, the applicant enhanced the ASME Code Section XI, Subsection IWL AMP to demonstrate that the effects of ASR will be managed and that there is a reasonable assurance the concrete containment structure will adequately perform its intended function during the period of extended operation. The applicant also enhanced the “preventive actions,” “monitoring and trending,” and “acceptance criteria” program elements. In lieu of enhancing the “parameters monitored or inspected” and “detection of aging effects” program elements of the ASME Section XI, Subsection IWL AMP the applicant augmented this AMP by creating a new plant-specific “Alkali Silica Reaction Monitoring” AMP. In addition, the applicant also integrated portions of the Structures Monitoring AMP and the new plant-specific Building Deformation Monitoring AMP with the ASME Section XI, Subsection IWL AMP. The staff’s evaluation of the ASR-related AMPs are in Sections 3.0.3.3.6 and 3.0.3.3.7, respectively.

The Seabrook containment is a concrete cylinder topped with a hemispherical dome, supported on a reinforced concrete foundation mat. The containment is encapsulated within the containment enclosure building, which is also a concrete cylinder with a hemispherical dome. There is an annular space of five feet between the containment and the containment enclosure building. The below grade portion of the containment is not in contact with the soil or ground water. However, for some time in the past, the bottom six feet of the concrete containment was in contact with groundwater that leaked through the containment enclosure building and filled the annular space. The groundwater from this area has since been removed, and the applicant has committed to keep this annular space dry in the future. Isolated areas of the concrete containment that were previously exposed to the groundwater have indications of cracking.

The staff’s June 8, 2012, SER with open items (OIs) discusses the staff’s concerns regarding whether the applicant would: (1) take adequate measures to preserve the integrity of the concrete containment structure through testing and evaluation of its cracked area to determine if the cracks are due to ASR (OI 3.0.3.2.18-1); and (2) dewater the annular space between the containment and containment enclosure buildings (OI 3.0.3.1.9-1). The staff concerns identified in OI 3.0.3.1.9-1 are briefly discussed below in the staff evaluation of *Enhancement 2*, and fully discussed and resolved in SER Section 3.0.3.1.9. The staff’s concerns associated with OI 3.0.3.2.18-1 have also been briefly discussed in the Staff Evaluation of *Enhancement 2 (Deleted)* and in the Operating Experience section below. The staff’s comprehensive discussion and resolution of OI 3.0.3.2.18-1 is documented in SER Section 3.0.3.2.18.

Staff Evaluation. This section of the SER addresses the staff's review and evaluation of the applicant's ASME Section XI, Subsection IWL AMP for the Seabrook concrete containment structure only. However, this AMP also references the LRA Section B.2.1.31, “Structures Monitoring;” LRA Section B.2.1.31A, “Alkali Silica Reaction Monitoring;” and LRA Section B.2.1.31B, “Building Deformation Monitoring” AMPs, reviewed and evaluated in SER Sections 3.0.3.2.18, 3.0.3.3.6 and 3.0.3.3.7, respectively.

During its LRA audit, the staff reviewed the applicant’s claim of consistency of its ASME Section XI, Subsection IWL AMP with that of the GALL Report AMP XI.S2. The staff compared program elements one through six of the applicant’s program with the corresponding program elements of GALL Report AMP XI.S2. As discussed in the LRA audit report dated March 21, 2011

(ADAMS Accession No. ML110280424), the staff confirmed that each program element of the applicant’s AMP is consistent with the corresponding program element of GALL Report AMP XI.S2, with the exception of the “acceptance criteria” program element. For this program element the staff determined the need for additional information, which resulted in the issuance of RAIs discussed below.

The “acceptance criteria” program element in GALL Report AMP XI.S2 recommends that acceptance standards for evaluation of concrete containments follow IWL-3000 of the ASME Code Section XI. Acceptance of concrete surfaces rely on the “responsible engineer,” who in accordance with IWL-2320 and IWL-2310 is a registered professional engineer that performs general visual examinations in sufficient detail to identify concrete “deterioration and distress, such as defined in ACI 201.1.” The GALL Report AMP XI.S2 provides added guidance to these ASME Code Section XI requirements augmenting the qualitative assessment of ACI 201.1 with the quantitative acceptance criteria of ACI 349.3R, Chapter 5. During its audit the staff was not clear how the degradation of the concrete containment has been quantified, tracked, and trended for use as a baseline for the period of extended operation. The staff reviewed the preventive maintenance work orders used for tracking and identifying conditions (a sample of which are discussed in the audit report), and the site procedure that describes acceptance criteria for concrete containment surface evaluations. The staff noted that the applicant does not implement the three-tier evaluation criteria of Chapter 5 of ACI 349.3R. The staff also noted that visual inspections of the concrete containment indicated areas of spalled concrete that equaled or exceeded a depth of 1 in. In accordance with in ACI 349.3R-02, Section 5.1, spalled areas that exceed a depth of 3/8 in., and 4 in. in any dimension, must be evaluated.

By letter dated November 18, 2010 (ADAMS Accession No. ML103090558), the staff issued RAI B.2.1.28-1 requesting that the applicant provide details on: (1) methods used to identify containment concrete surface conditions and how these conditions are tracked, trended, and evaluated; and (2) the frequency of examinations and whether acceptance criteria followed, and actions taken, are in conformance with ASME Code Section XI, Subsection IWL, and NRC IN 2010-14, “Containment Concrete Surface Condition Examination Frequency and Acceptance Criteria.”

In its response dated December 17, 2010 (ADAMS Accession No. 103540534), the applicant stated that:

> Any Containment concrete degradation identified during IWL Examinations is documented (per the implementing procedure) on Examination Forms, using the guidance of ACI 349.3R and ACI 201.1R for condition quantification, description and terminology. The degraded area is marked in the field with an identifying label to guide the Responsible Engineer's review, and subsequent Examination review. An Action Request (AR) is generated for Examination Forms that document degradation, requiring an Evaluation by the Responsible Engineer. The Forms and Evaluations are retained and reviewed prior to the next Examination. During the subsequent Examination, previously reported areas are re-examined to determine if there has been any change in their condition.
>
> The retained Forms and Evaluations from each successive Examination will be maintained up to and through the Period of Extended Operation, thereby creating a continuous record of the condition of the Containment concrete.

With regards to IN 2010-14 the applicant stated that the “Seabrook Inservice Inspection Procedure Primary Containment Section XI IWL Program” was revised in October of 2010 to “include the guidance of ACI 201.1R and ACI 349.3R for identifying degradation during [g]eneral [v]isual [e]xaminations.” The staff finds that the revision made to the “Seabrook Inservice Inspection Procedure Primary Containment Section XI IWL Program,” to include the quantitative guidance of ACI 349.3R is acceptable because the implemented acceptance criteria of Chapter 5 of ACI 349.3R make the AMP consistent with GALL Report AMP XI.S2. The staff’s concern described in RAI B.2.1.28-1 is resolved.

The staff also was not clear how areas of spalling are evaluated. Therefore, by letter dated November 18, 2010, the staff issued RAI B.2.1.28-2 requesting that the applicant describe methods used to evaluate spalled areas that exceed: (1) a depth of 3/8 in. and 4 in. in any dimension for “Acceptance After Review”; and (2) a depth of 3/4 in. and 8 in. in any dimension for “Conditions Requiring Further Evaluation” criteria delineated in Chapter 5 of ACI 349.3R-02. In addition, the staff requested the applicant to provide findings from the most recent engineering evaluation report prepared in compliance with ASME Section XI, IWL requirements.

The applicant responded to RAI B.2.1.28-2 in a letter dated December 17, 2010, and stated that prior to August 18, 2010, Seabrook conducted the IWL examinations in accordance with ASME Code Section XI, Subsection IWL, 1995 Edition with 1996 Addenda with deficiencies reported in qualitative terms and evaluations performed by the responsible engineer, a licensed professional engineer, using the methodology described in the RAI B.2.1.28-1 response. The staff also noted that since September of 2010 IWL examinations were performed in accordance with ASME Code Section XI, 2004 Edition and no Addenda, and the recommended guidance of ACI 201.1R and ACI 349.3R. The staff further noted that the Responsible Engineer performed evaluations and quantified identified deficiencies per ACI 349.3R. In its response, the applicant also provided the following summary of findings from the September 2010 IWL examination:

> Five Action Requests (ARs) were issued during the ASME Code Section XI, IWL examinations of the Containment concrete; eighty-four (84) deficient areas were identified that required an Engineering Evaluation.
>
> Each of the reported discontinuities in the Containment concrete were individually reviewed and evaluated by Design Engineering. All of the reported discontinuities were accepted-as-is with no further technical evaluation or remediation, based on the criteria of ACI 349.3R.

The staff finds the use of acceptance criteria in ACI 349.3R to evaluate concrete containment deficiencies and discontinuities acceptable, because it makes the applicant's AMP consistent with GALL Report AMP XI.S2. The staff's concern described in RAI B.2.1.28-2 is resolved.

The staff also reviewed the portions of the "acceptance criteria," "preventive actions," and "parameters monitored or inspected" program elements associated with enhancements to determine if the program will be adequate to manage the effects of aging for which it is credited. The staff's evaluation of these enhancements follows.

Enhancement 1. LRA Section B.2.1.28 includes an enhancement to the "acceptance criteria" program element. The applicant stated that the enhancement involves the definition of "Responsible Engineer" (i.e., Registered Professional Engineer) to be included in the applicant's procedure for implementing its ASME Section XI, Subsection IWL AMP, as outlined in Commitment No. 31.

The staff reviewed this program element enhancement against the corresponding program element in GALL Report AMP XI.S2 and finds it acceptable, because when it is implemented it will require the responsible engineer to be a "Registered Professional Engineer" in accordance with IWL-2310 and this is consistent with the "acceptance criteria" program element of GALL Report AMP XI.S2.

Enhancement 2 (Deleted). By letter dated December 17, 2010, in response to RAI B.2.1.28-3, evaluated and dispositioned by the staff in the "Operating Experience" section below, the applicant revised LRA Section B.2.1.28 to include an enhancement to the "parameters monitored or inspected" program element. The applicant stated that through this enhancement it would perform confirmatory testing and evaluation to determine the concrete compressive strength, the presence or absence of ASR, the concrete modulus of elasticity, and the presence or absence of rebar degradation of the containment structure concrete prior to the period of extended operation. However, by letter dated August 11, 2011 (ADAMS Accession No. ML11227A023), in its response to RAI Follow-up B.2.1.28-3, evaluated and dispositioned by the staff in the "Operating Experience" section below, the applicant deleted this enhancement and the associated (at the time) Commitment No. 51 from the LRA, with the justification that:

> Program enhancement and commitment to confirmatory testing cannot be made until aging effects due to ASR are fully understood […and a] "planned approach addressing ASR degradation throughout the site [would] be included in an engineering evaluation scheduled to [be] complete[d] in March of 2012 […with] [p]lans to monitor the extent of cracking and expansion in concrete.

By letter dated May 16, 2012 (ADAMS Accession No. ML12142A323), the applicant supplemented the LRA with a new plant specific AMP, augmenting LRA Section B.2.1.31, "Structures Monitoring," and documented as LRA Section B.2.1.31A, "Alkali-Silica Reaction [ASR] Monitoring," to manage the effects of aging due to ASR (i.e., cracking due to expansion and reaction of cement with aggregates) in concrete structures.

The staff reviewed the applicant's deletion of Enhancement No. 2 and Commitment No. 51 and determined that it needed additional information for the proposed plant-specific ASR Monitoring AMP. The final revision of the ASR Monitoring AMP and associated RAIs for that AMP are reviewed and evaluated by the staff in SER Section 3.0.3.3.6. The staff finds that the deletion of this enhancement and corresponding Commitment No 51 is acceptable because the applicant has created a new plant-specific ASR Monitoring AMP that the staff finds acceptable for monitoring the extent of cracking and expansion of aggregates in concrete due to ASR.

This issue, previously identified in the SER with Open Items as OI 3.0.3.2.18-1, based on the above, is resolved and the open item is closed. Additional basis for staff closure of this OI is discussed in the Operating Experience section below.

Enhancement 2 (identified as Enhancement 2 in LRA Supplement 60 dated February 28, 2018, but identified as Enhancement 3 in LRA letter dated December 17, 2010, and SER with OI). By letter dated December 17, 2010, the applicant revised LRA Section B.2.1.28 to include an enhancement to the "preventive actions" program element. This enhancement involves implementing measures to maintain the exterior surface of the containment structure from elevation -30 ft. to +20 ft. in a dewatered state. In addition, the applicant committed (Commitment No. 52) to implement these measures prior to the period of extended operation. Specifics on the origin of this enhancement are discussed in the Operating Experience section below. Subsequently, by letters dated April 14, 2011; April 22, 2011; September 13, 2013 (ADAMS Accession Nos. ML11108A131, ML11115A116, ML13261A145), the applicant revised the implementation date of Commitment 52, and in Supplement 60 dated February 28, 2018, it stated that the commitment was completed.

The staff reviewed this enhancement against the corresponding program element in GALL Report AMP XI.S2. The staff noted that no preventive actions are specified in GALL Report AMP XI.S2 for concrete degradation. However, maintaining the exterior surface of the containment structure from elevation -30 ft. to +20 ft. in a dewatered state is an appropriate preventive action because it will ensure that the exterior surface of the concrete containment will not be exposed to water that could contribute to cracking due to expansion from reaction with aggregates. The staff also noted that during September of 2011 NRC inspectors examined the subject area and found the exterior surface of the containment to be in a dewatered state with sump pumps used to dewater the area. Therefore, the staff finds this enhancement and Commitment No. 52 to be acceptable, because it has been completed and it eliminates the constant exposure of concrete containment and the concrete containment enclosure building to groundwater, thus mitigating further degradation of concrete due to ASR.

The staff also finds OI 3.0.3.1.9-1 closed because the applicant completed the Commitment action to maintain the annulus region between the containment and containment structure in a dewatered state thus mitigating potential additional aging effects of aggregate expansion due to ASR, as noted in the *(Deleted) Enhancement 2* above. OI 3.0.3.1.9-1 is resolved and staff's closure of the open item is documented in SER Section 3.0.3.1.9, "ASME Section XI, Subsection IWE."

Enhancement 3. By letter dated February 28, 2018, the applicant revised LRA Section B.2.1.28 to include an enhancement to the "monitoring and trending" program element and a corresponding commitment (Commitment 55) to be fulfilled by September 1, 2020. The LRA states that implementation of this enhancement ensures that concrete containment suspect distress areas from the 2010 and 2016 ASME Section XI, IWL inspections are incorporated appropriately into the next revision of the Seabrook Station Containment Inservice Inspection (CISI) Plan. This enhancement was provided in response to RAI B.2.1.28-5, which is evaluated and dispositioned by the staff in the Operating Experience section below.

The staff reviewed this enhancement and Commitment No. 55 and finds the applicant's approach to register the visually identified suspect concrete surface areas from the 2010 and 2016 ASME Section XI, Subsection IWL, inspections into the next revision of its CISI Plan acceptable, because: (1) these areas have been selected through general and detailed visual examinations in accordance with the tiered acceptance criteria of ACI 349.3R, further amplified by monitoring CCI and/or measurement of distinct individual crack widths to assess ASR progression; and (2) examinations are in accordance with L1.11, "Concrete Surface-All Accessible Surface Areas," and L1.12, "Concrete Surface Suspect" of Table IWL 2500-1 of ASME Code Section XI requirements, that also satisfy the "monitoring and trending" program element criteria of GALL Report AMP XI.S2. The staff also finds completion of Commitment 55 by September 1, 2020, acceptable because the next revision of the applicant's CISI Plan would be in accordance with the regulatory requirements of 10 CFR 50.55a, incorporating the latest Edition of ASME Code Section XI (currently 2013 Edition with noted exceptions) 12 months prior to the start of the 120-month inspection interval scheduled to begin August 19, 2020.

Based on its audit and review of the applicant's responses to RAI B.2.1.28-1 and RAI B.2.1.28-2, the staff finds that program elements one through six for which the applicant claimed consistency with the GALL Report are consistent with the corresponding program elements of the GALL Report AMP XI.S2. In addition, the staff reviewed the enhancements associated with the "acceptance criteria," "preventive actions," and "monitoring and trending" program elements, along with steps taken replacing *Enhancement 2 (Deleted)* referencing the "parameters monitored and inspected" program element with a new plant specific ASR Monitoring AMP, and finds that when these are implemented they will make the AMP adequate to manage the applicable aging effects.

<u>Operating Experience</u>. LRA Section B.2.1.28 summarizes operating experience related to the ASME Section XI, Subsection IWL AMP. The applicant stated that this program is implemented through the "Seabrook Station Containment Surface Inspection Program," and that the containment structure concrete has been found to be in good condition during inspections performed in accordance with ASME Code Section XI, Subsection IWL. The applicant further stated that containment inspections performed in 2002, 2005, and 2008 "were completed satisfactorily with no indication of degradation of the concrete surfaces."

The staff reviewed operating experience information in the application and during the audit to determine if the applicable aging effects and industry and plant-specific operating experience were reviewed by the applicant. As discussed in the audit report, the staff conducted an independent search of the plant operating experience information to determine if the applicant had adequately evaluated and incorporated operating experience related to this program.

During its review, the staff identified operating experience indicating that the applicant's ASME Section XI, Subsection IWL Program may not be effective to adequately manage the aging effect of cracking due to expansion from reaction with aggregates (i.e., ASR) during the period of extended operation. The staff determined the need for additional clarifications, which resulted in the issuance of RAIs.

In LRA Section B.2.1.28 the applicant stated that concrete degradation due to aggressive chemical attack is an aging effect applicable to Seabrook, and that the Structures Monitoring Program addresses the plan and specific details to determine the effects of aggressive chemical attack on the concrete. The applicant further stated that an evaluation would be conducted after the testing in the plan is performed, and, if required, actions would be provided using the corrective action process for concrete under the Structures Monitoring Program and the ASME Code Section XI, Subsection IWL AMP.

During the audit the staff found that initial testing results for concrete samples obtained from below-grade areas of other safety-related structures indicate that the concrete in these areas is exhibiting cracking due to ASR. The staff also found that groundwater migrated into the annular space between the concrete enclosure building and concrete containment, and the bottom 6 ft. of the concrete containment wall was in contact with the groundwater for an extended period of time. Furthermore, cracks due to ASR have been observed in different Seabrook plant concrete structures, including the concrete containment enclosure building. Although water is a contributing factor to cement-aggregate reactions as discussed in ACI 349.3R-02, Section 4.2.5, the applicant stated that the containment concrete in the annulus does not exhibit evidence of cracking due to expansion and reaction with aggregates. A review of Seabrook condition reports by the staff (a sample of which are documented in the audit report) did not identify inspection findings that discussed cracking of concrete due to expansion and reaction with aggregates or nondestructive or destructive test data that quantify the magnitude or extent of cracking of accessible above-grade and below-grade portions of the concrete containment.

The staff noted that ASR might be occurring in the containment, particularly in the areas that were previously wetted. Therefore, by letter dated November 18, 2010, the staff issued RAI B.2.1.28-3 requesting additional information to determine how the effects of aging for aggregate expansion due to ASR in the concrete containment would be managed so that its intended function will be maintained for the period of extended operation. The staff requested that the applicant provide information about the test method or procedure used to: (1) confirm that the exterior containment concrete surface between elevation -30 ft. and +20 ft. is not experiencing cracking due to expansion and reaction of cement paste with aggregates; and (2) verify that the compressive strength and modulus of elasticity of the concrete containment at these elevations are not affected by cracking due to expansion and reaction with aggregates. In addition, the staff requested the applicant to provide results of any existing or planned compressive, tensile, and modulus of elasticity concrete tests of core samples taken from the concrete containment between elevation -30 ft. and +20 ft.

In its response dated December 17, 2010, the applicant stated that the 2010 ASME Section XI, Subsection IWL five year inspection of the Containment Structure yielded "no sign of detrimental cracking in the Containment Structure based on the inspection performed using the guidance of ACI 349.3R." The applicant also stated that "[i]n the absence of detrimental cracking, there has been no reasonable expectation for loss of compressive strength or loss of modulus of elasticity." The applicant further stated that it would perform confirmatory testing and evaluation of the containment structure concrete, reflected in its Commitment No. 51, to "determine the concrete compressive strength, the presence or absence of […] ASR, the concrete modulus of elasticity, and the presence or absence of rebar degradation. The testing and evaluation […would] be completed prior to the period of extended operation." In addition, the applicant stated that prior to the period of extended operation it would "implement measures to maintain the exterior surface of the Containment Structure, from elevation -30 feet to +20 feet, in a dewatered state." To this end, the applicant proposed a new Enhancement 2 and Commitment No. 52, reviewed and evaluated above.

Based on its review, the staff found the applicant's response to RAI B.2.1.28-3 concerning confirmatory testing and evaluation of the concrete Containment Structure unacceptable, because the applicant's Commitment No. 51, to just perform confirmatory testing and evaluation of the containment structure prior to the period of extended operation (March 15, 2030), would only support portions of program elements of GALL Report AMP XI.S2, "ASME Section XI, Subsection IWL," with which the applicant professed consistency in the LRA.

In a letter dated April 14, 2011, the applicant clarified its initial response to RAI B.1.28-3 and referenced inspection IP 71002. In its clarification response the applicant added several rows to Table 2.4-2 and AMR items to Table 3.5.2-2 in the LRA, for material/environment of concrete in raw water for the containment building. The applicant also stated that the clarification and changes to the LRA were needed to manage the effects of aging of the concrete containment so that its intended function would be maintained consistent with the CLB for the period of extended operation.

Contrary to the applicant's additional input, also summarized in its response to RAI B.2.1.28-3 that there was "no sign of detrimental cracking in the Containment Structure," the staff noted that the IP 71002 inspection report (ADAMS Accession No. ML111360432) dated May 23, 2011 identified weaknesses in the in the ASME Section XI, Subsection IWL AMPs and the existence of crazed pattern cracking in the annulus area of the containment. In addition, the report documented the lack of existence of a technically acceptable trending system to establish the status of observed cracks (stable or active). Therefore, by letter dated June 29, 2011, the staff issued Follow-up RAI B.2.1.28-3 (ADAMS Accession No. ML11178A338) regarding the status of the initial Enhancement 2 and Commitment No. 51, requesting the existence of plans, if any, to monitor the extent of cracking and expansion of aggregates in concrete. In its response to Follow-up RAI B.2.1.28-3, dated August 11, 2011, the applicant stated that it deleted its Enhancement 2 and Commitment No. 51 for confirmatory testing, reviewed and evaluated in (Deleted) Enhancement 2 above, because of its ongoing effort to develop a planned approach to testing and mitigation techniques to be included in an engineering evaluation scheduled to be completed in March 2012.

In a subsequent letter dated March 30, 2012 (ADAMS Accession No. ML12094A364), the applicant supplemented its initial response to RAI B.2.1.28-3 on testing method or procedure used to identify whether the wetted portion of the containment building structure is experiencing cracking due to ASR, and on past and future testing to verify the concrete strength of the wetted area. The applicant stated that the ASME Section XI, Subsection IWL five year inspection of the containment structure was performed in 2010, with additional inspections of the exterior surface of the containment structure performed in September 2011 using the guidance of ACI 349.3R, where no signs of detrimental cracking were found. The applicant also stated that the additional inspections of the exterior surface of the containment structure showed that a "maximum crack width of 8 mils, which is less than the 15 mil criteria for acceptance without further evaluation in the first-tier of the Structural Monitoring Program. Inspections revealed two isolated Containment exterior surface that exhibit pattern cracking that may be indicative of ASR." The applicant further stated that:

> Although the identified crack width does not meet the Structural Monitoring Program threshold for further evaluation, these two locations will be included in the second-tier evaluation criteria of the program due to the past groundwater in- leakage and follow-up inspections will be performed. Any identified crack growth will require additional evaluation.

The applicant stated that "in the absence of detrimental cracking, there has been no reasonable expectation for loss of compressive strength or loss of modulus of elasticity." However, the applicant stated that it would:

> [P]erform confirmatory testing and evaluation of the Containment Structure concrete. The testing and evaluation will determine the concrete compressive strength, the presence or absence of […] ASR, the concrete modulus of elasticity, and the presence or absence of rebar degradation. The testing and evaluation will be completed […and] measures [taken] to maintain the exterior surface of the Containment Structure, from elevation -30 feet to +20 feet, in a dewatered state […] prior to the period of extended operation.

Furthermore, the applicant stated that core samples have not been taken for testing and were not planned in the near future, and that indications of cracking were minor.

The staff reviewed the applicant's responses to RAIs B.2.1.28-3 and Follow-up RAI B.2.1.28-3 and found these unacceptable because the applicant had not confirmed if the cracks are passive or active. The applicant stated that the crack pattern might be due to ASR, which is indicative of active cracking. The staff notes that active cracking observed in a structure is required to be investigated because cracking damage can continue or intensify. The staff also notes that the 15 mil crack width acceptance criteria noted in Section 5.1 of ACI 349.3R and referenced in GALL Report AMP, XI.S6, "Structures Monitoring Program," is for passive cracks, which are defined as those lacking recent growth and a crack driving or other degradation mechanism.

By letter dated November 18, 2010, the staff issued RAI B.2.1.28-4 requesting that the applicant provide plans and schedules for the following:

- conducting a baseline inspection of the condition of accessible above-grade and below-grade portions of the concrete containment in accordance with ACI 349.3R requirements

- obtaining nondestructive or destructive test data for quantifying the mechanical properties (compressive strength, tensile strength, and modulus of elasticity) of concrete in areas that have experienced cracking due to expansion and reaction with aggregates

In its response dated December 17, 2010, the applicant stated that:

> The most recent ASME Section XI, Subsection IWL examination of containment concrete was completed in October 2010. This examination of the Containment concrete consisted of General Visual and Detailed Visual examinations consistent with the criteria in ACI 201.1-92 and ACI 349.3R-02. These two ASME IWL concrete examinations […would] serve as the baseline for future examinations of containment concrete, which are performed at 5 year intervals. The containment is enclosed by the containment enclosure building, and the inspection is based on one environment which is air-indoor uncontrolled.

For the requested information on measures that the applicant would take to determine the integrity of the containment concrete and steel reinforcing bars in areas that have experienced cracking due to expansion and reaction with aggregates, the applicant stated that such information was provided in its response to RAI B.2.1.28-3.

The staff identified these previously unresolved issues as OI 3.0.3.2.18-1, in its SER with OIs issued on June 2012. The staff noted that, as discussed above in (Deleted) Enhancement 2, these issues are now resolved and OI 3.0.3.2.18-1 is closed.

Update to the Operating Experience.

By letter dated July 20, 2017, the applicant submitted Supplement 56 (ADAMS Accession No. ML17201A036) revising the LRA AMP B.2.1.28 "Operating Experience" program element to include results from its 2016 IWL examination. In the updated operating experience, the applicant stated that observed indications during inspections had no adverse impact on the structural integrity or structural performance of the containment structure and no ASME Code Repair activities were required as a result of the ASME IWL examination. The staff reviewed the applicant's input and noted that in 2010 Seabrook implemented the recommendations of Information Notice (IN) 2010-14, "Containment Concrete Surface Condition Examination Frequency and Acceptance Criteria," to visually inspect, identify, track, and evaluate concrete containment deterioration in accordance with ACI 349.3R (referenced also by the plants current ASME Code, Section XI, IWL-2310). The Seabrook Inservice Inspection Reference (SIIR) (ADAMS Accession No. ML 11180A079) and its CISI Plan for IWL, "Examination Category L-A Concrete," however, did not appear to provide any specifications for ASME identifier L 1.12, "Concrete Surface Suspect Areas," which would require detailed visual examination. Furthermore, in License Amendment Request 16-01, "Request to Extend Containment Leakage Test Frequency," (ADAMS Accession No. ML 16095A278) the applicant stated that the CCI "met the action level criterion necessitating a structural evaluation." The staff noted that it needed additional information to understand why, if ASR cracking necessitated a structural evaluation, that those areas were not identified as "Concrete Surface Suspect Areas" in the IWL program.

By letter dated January 29, 2018 (Accession Number ML18026A879), the staff issued RAI B.2.1.28-5 requesting that the applicant provide information regarding why: (1) the plant appears to limit its IWL visual examinations to "general visual," even though the requirements for IWL-2310 call for "detailed visual" examinations to determine the magnitude and extent of deterioration and distress of suspect concrete surface areas; (2) the identified distressed concrete containment surface areas in the referenced LAR above have not been included as surface areas subject to detail visual examination and reported in the operating experience program element of LRA Section B.2.1.28; and (3) areas identified as “Tier 2” or “Tier 3” and requiring measurement of the extent of degradation by CCI and crack width are not being considered “suspect areas” and if so to provide justification for their exclusion.

In its response dated February 28, 2018, the applicant stated that it performs general visual examinations in sufficient detail and in accordance with the requirements of ASME Section XI, IWL-2310 and Table IWL-2500-1, to assess the general structural condition of the containment and identify areas and types of concrete deterioration and distress, as described in ACI 201.1 and ACI 349.3R. It then follows by Detailed Visual Examinations for noted evidence of pattern cracking on the surface of the concrete, secondary deposits at the pattern cracking location, dark staining adjacent to the cracks, and gel exudation in the cracks. The applicant also stated that these examinations are performed to determine: (1) the magnitude and extent of deterioration or distress of suspect concrete surfaces as identified in ACI 349.3R; (2) the condition of concrete surfaces affected by repair/replacement activities prior to pressure testing; and (3) the condition of reinforcing steel exposed as a result of removal of defective concrete during repair/replacement activities. The applicant further stated that results of detailed visual examination are documented and submitted to the Responsible Engineer for evaluation and disposition. Acceptance of surface conditions by examination, evaluation, or repair/replacement follows IWL-3200 and IWL-3300, when applicable. The applicant then stated that suspect areas identified during the 2010 IWL inspection that required a detailed visual inspection and subsequent engineering evaluation were accepted without an ASME IWL-3300 Engineering Evaluation. However, the applicant enhanced (Enhancement 3) the “monitoring and trending,” program element of this AMP and committed (Commitment No. 55) to incorporate all “Concrete Surface - Suspect Areas identified from the 2010 and 2016 ASME Section XI, IWL inspections […] into the next revision of […its] CISI Plan,” by September 1, 2020. The applicant also stated that ASR suspect areas, regardless of their Tier state, are documented as part of IWL examination but evaluated, monitored, and trended in accordance with the Structures Monitoring Program.

The staff reviewed the response to RAI B.2.1.28-5 and found it acceptable because the applicant: (1) performs general visual and detailed visual examinations as required by ASME Code Section XI, Subsection IWL using the guidance of ACI 201.1 and ACI 349.3R to detect, identify, monitor, and trend deteriorated and distressed concrete surface areas for a number of aging effects that include ASR; (2) commits to incorporate identified areas of distress of the concrete containment surface found during its 2010 and 2016 ASME Section XI, IWL inspections into its CISI plan; and (3) will document all potential ASR identifications in the IWL data base and evaluate these in accordance with the Structures Monitoring Program regardless of their Tier classification. The staff’s concern described in RAI B.2.1.28-5 is resolved.

Based on its audit and review of the application, and review of the applicant’s response to RAIs B.2.1.28-3, Follow-up RAI 2.1.28-3, RAI B.2.1.28-4, and RAI B.2.1.28-5, the staff finds that the applicant has appropriately evaluated plant-specific and industry operating experience, and that operating experience related to the applicant’s program demonstrates that the program can adequately manage the effects of aging on SSCs within the scope of the program, and that implementation of the program has resulted in the applicant taking corrective actions.

<u>UFSAR Supplement</u>. LRA Section A.2.1.28 as amended by letter dated May 15, 2014 (ADAMS Accession No. ML14142A220), provides the UFSAR supplement for the ASME Code Section XI, Subsection IWL AMP. The staff reviewed the amended UFSAR supplement description of the program and noted that it conforms to the recommended description for this type of program, as described in SRP-LR Table 3.5-2.

The staff also noted that the applicant committed to enhance the ASME Code Section XI, Subsection IWL AMP prior to entering the period of extended operation with Commitment Nos. 31, 52, 55, and 84 sequenced below:

- Include the definition for “Responsible Engineer” in its procedure for implementing its ASME Code Section XI, Subsection IWL AMP;
- Implement measures to maintain the exterior surface of the containment structure, from elevation -30 ft. to +20 ft., in a dewatered state. The staff notes that as discussed in Enhancement 2 above, by letter dated February 28, 2018, the applicant stated that Commitment 52 was completed;

- Incorporate into the Seabrook CISI Plan ASR suspect concrete surface areas identified during the 2010 and 2016 IWL containment inspections, prior to September 1, 2020; and
- Evaluate the acceptability of inaccessible areas for structures within the scope of ASME Section XI, Subsection IWL AMP.

The staff finds that the information in the amended UFSAR supplement is an adequate summary description of the program, as required by 10 CFR 54.21(d).

Conclusion. On the basis of its audit and review of the applicant's ASME Section XI, Subsection IWL Program, the staff determines that those program elements for which the applicant claimed consistency with the GALL Report are consistent. Also, the staff reviewed the enhancements and confirmed that their implementation through Commitments No. 31, 52, 55, and 84 prior to the period of extended operation will make this AMP adequate to manage the applicable aging effects. The staff concludes that the applicant has demonstrated that the effects of aging will be adequately managed so that the intended function(s) will be maintained consistent with the CLB for the period of extended operation, as required by 10 CFR 54.21(a)(3). The staff also reviewed the UFSAR supplement for this AMP and concludes that it provides an adequate summary description of the program, as required by 10 CFR 54.21(d).

3.0.3.2.18 Structures Monitoring Program

Summary of Technical Information in the Application. LRA Section B.2.1.31 describes the existing Structures Monitoring Program as being consistent, with enhancements, with GALL Report AMP XI.S6, "Structures Monitoring Program." In the LRA, the applicant stated that AMP B.2.1.31, "Structures Monitoring Program," is implemented through the Seabrook Maintenance Rule Program and integrates the Masonry Wall Program and RG 1.127, "Inspection of Water-Control Structures Associated with Nuclear Power Plants," Program. These programs are existing and consistent with the program elements in GALL Report AMP XI.S5, "Masonry Wall Program," GALL Report AMP XI.S6, "Structures Monitoring Program," and GALL Report AMP, XI.S7, "RG 1.127, Inspection of Water-Control Structures Associated with Nuclear Power Plants," with enhancements.

In the LRA, the applicant stated that the Structures Monitoring Program includes periodic visual inspections of structures and structural components for the detection of aging effects specific to the particular structure at a frequency determined by the characteristics of the environment in which the structure is located. These inspections are performed at an interval not to exceed 5 years (plus or minus 1 year) for structures in a harsh environment. The applicant also stated that a harsh environment is defined as one that is in an area that is routinely subjected to outside ambient conditions of very high temperature, high moisture or humidity, frequent large cycling of temperatures, frequent exposure to caustic materials, or extremely high radiation levels. Structures not found in areas qualifying as a harsh environment are classified as being in a mild environment and are inspected on a 10-year basis. Individuals performing the inspections and interpreting the results have expertise in the design and inspection of steel, concrete, and masonry structures and are either licensed professional engineers experienced in this area or will be working under the direction of a licensed professional engineer with expertise in this area. The applicant further stated that parameters monitored meet the requirements of ACI 349.3R-96, "Evaluation of Existing Nuclear Safety-Related Concrete Structures," and ASCE 11-90, "Guideline for Structural Condition Assessment of Existing Buildings." Identification of concrete deficiencies is based on guidance provided in ACI 201.1R-2, "Guide for Making a Condition Survey of Concrete in Service," and acceptance guidelines use a three-tier hierarchy similar to that described in ACI 349.3R-96 (i.e., acceptable, acceptable with deficiencies, or unacceptable).

In the LRA, the applicant stated that aggressive subsurface environments are monitored by sampling the groundwater at 5-year intervals for chloride concentration, sulfate concentration, and pH. Inaccessible areas, such as buried concrete foundations, will be examined during inspections of opportunity or during focused inspections at 5-year intervals. The applicant also stated that, although Seabrook has no block or concrete masonry walls used in Category I structures, masonry walls in structures and buildings (fire pumphouse, nonessential switchgear room, turbine building and yard structure station blackout (SBO)) performing nonsafety-related functions are monitored for cracking and evaluated under the Structures Monitoring Program. Periodic visual inspections of water-control and flood protective structures are within the scope of the Structures Monitoring Program and are inspected under the Maintenance Rule Program.

During the course of the staff's review, the applicant submitted amendments to the application, and these are discussed in the staff's evaluation below, as appropriate.

Summary of Staff Evaluation. The staff has reviewed the various elements of the Structures Monitoring Program and found them to be consistent with corresponding elements of the GALL Report AMP; however, based on the lack of understanding of ASR) and its impacts, the staff determined that the applicant needs to enhance the Structures Monitoring Program to manage the effects of ASR. The enhancements are required to the program elements "parameters monitored or inspected," "detection of aging effects," "monitoring and trending," and "acceptance criteria." This issue was identified as Open Item OI 3.0.3.2.18-1.

By letter dated May 16, 2012, the applicant submitted a new plant-specific AMP, the ASR Monitoring Program, to demonstrate that cracking due to expansion from reaction with aggregates will be adequately managed during the period of extended operation. The staff's review of the ASR Monitoring Program is in Section 3.0.3.3.6. By letter dated August 9, 2016, the applicant submitted an additional plant-specific aging management program, the Building Deformation Monitoring Program, to demonstrate that global effects of building deformation and macro cracking will be adequately managed during the PEO. The staff's review of the Building Deformation Monitoring Program is documented in SER Section 3.0.3.3.7. Based on the staff evaluation of these two plant-specific AMPs that addressed the aging effects due to ASR, Open Item OI 3.0.3.2.18-1 is closed.

Staff Evaluation. This section of the SER addresses the staff's review and evaluation of the applicant's aging management program for all license renewal in-scope concrete structures and masonry walls at Seabrook plant except for the concrete containment structure. The aging management program for the containment structure is described in Section 3.0.3.2.17 of this SER.

During its audit, the staff reviewed the applicant's claim of consistency with the GALL Report. The staff also reviewed the plant conditions to determine if they are bounded by the conditions for which the GALL Report was evaluated.

The staff compared elements one through six of the applicant's program to the corresponding elements of GALL Report AMPs XI.S5, XI.S6, and XI.S7. As discussed in the audit report, the staff confirmed that each element of the applicant's program is consistent with the corresponding element of GALL Report AMPs XI.S5, XI.S6, and XI.S7.

The staff also reviewed the portions of the "scope of program," "parameters monitored or inspected," "detection of aging effects," and "monitoring and trending" program elements associated with enhancements to determine if the program will be adequate to manage the aging effects for which it is credited. The staff's evaluation of the enhancements follows.

The staff noted that inclusion of opportunistic and focused inspections on a 5-year interval addresses GALL Report recommendations for examination of exposed portions of the below-grade concrete when excavated for any reason and development of a plant-specific AMP for plants with aggressive groundwater and soil that have experienced degradation. However, the staff also noted that the applicant inspected the remaining in-scope structures on a 5- or 10-year basis, depending on the structure's environment. The staff believes it may be acceptable to inspect structures on an interval greater than 5 years; however, the applicant must provide a list of the structures inspected under the longer interval along with a description of their environments and justification for the interval extension. Therefore, by letter dated January 5, 2011, the staff requested the applicant to identify the structures that will be inspected on a 10-year frequency along with their environments and a summary of past degradation.

In its response, dated February 3, 2011 (ADAMS Accession No. ML110380081), the applicant stated that a harsh environment is an area routinely subjected to outside ambient conditions, high moisture or humidity, very high ambient temperatures or frequent large cycling of temperatures (including freezing and thawing), frequent exposure to caustic materials, or extremely high radiation levels. A mild environment is one that is not harsh. The applicant further stated that, based on ACI 349.3R, the evaluation and inspection frequency varies according to the environment, from 5–10 years. In accordance with ACI-349.3R, the interior, above-grade portions of the following in-scope of license renewal structures are in a mild environment and, therefore, subject to a 10-year inspection frequency:

- the containment enclosure ventilation area
- the control building
- the diesel generator building
- the waste process building and tank farm (selected areas are harsh)
- the emergency feedwater pumphouse building including pre-action valve building
- the fuel storage building

- the primary auxiliary building (selected areas are harsh)
- the turbine generator building
- the fire pumphouse
- the steam generator blowdown recovery building
- the non-essential switchgear building

The applicant also stated that it classified the following structures, following ACI-349.3R guidance, to be in a harsh environment and, therefore, subject to a 5-year inspection:

- all in-scope below-grade structures (interior and exterior)
- all exterior above grade structures
- all structures inside primary containment
- designated areas of the tank farm and of the primary auxiliary building
- the service water pumphouse
- the circulating water pumphouse
- the intake transition structure
- the discharge transition structure
- the service water cooling tower revetment

The applicant then reiterated that the past degradation of these structures is discussed in the body of the program in the LRA.

The staff reviewed the applicant's response and found that it needed clarification regarding how frequently the spent fuel pool would be inspected and whether or not the inspection frequencies outlined in the response applied to all structures within the scope of the Structures Monitoring Program or just concrete components. The staff discussed these issues with the applicant during a conference call on March 18, 2011. By letter dated May 10, 2012, the applicant confirmed that the spent fuel pool is an in-scope below-grade structure and would be inspected on a 5-year frequency and that the inspection frequencies outlined in the RAI response dated February 3, 2011, applied to all in-scope structures, regardless of the material. The staff finds the applicant's response acceptable because the applicant confirmed the spent fuel pool is an in-scope below-grade structure and would be inspected on a 5-year frequency and it outlined which structures are subject to a 5-year or 10-year inspection, and it aligned the frequency with that recommended in ACI-349.3R, which provides the basis for industry standards. In addition the applicant confirmed that the 5-year or 10-year inspection frequency based on ACI-349.3R applies to all structures within the scope of the Structures Monitoring Program. The staff's concern discussed in RAI B.2.1.31-5 is resolved.

Enhancement 1. LRA Section B.2.1.31 states an enhancement to "scope of program" that expands the scope of the Structures Monitoring Program to add the following (the staff provides additional discussion on this enhancement later in this SER evaluation section, in reviewing the LRA amendments subsequent to the SER with open item issuance):

- inspection of elastomeric materials, aluminum, non-metallic fire proofing, and Lubrite®
- inspection of overhead and fuel handling cranes, NUREG-0612 cranes, all supports, tanks (1-FP-TK-35-A, 1-FP-TK-35-B, 1-FP-TK-36-A, 1-FP-TK-36-B, and 1-FP-TK-29-A) and their supports and foundations, fire house boiler building, safety- and nonsafety-related electrical cable manhole and duct bank yard structures, and two fire protection water storage tanks
- opportunistic and focused inspections of below-grade and inaccessible concrete at least once every 5 years

The staff finds the addition of the above-listed materials, the cranes and support tanks, and inspections of opportunity for below-grade and inaccessible concrete to be an acceptable enhancement because, when implemented, the Structures Monitoring Program will address the materials and structures included within the scope of license renewal. These specific enhancements bring the "scope of program" program element of the applicant's Structures Monitoring Program into partial compliance with the "scope of program" program element provided in GALL Report AMP XI.S6, "Structures Monitoring Program."

However, it was also not clear to the staff how frequently the tanks within the scope of the applicant's Structures Monitoring Program would be inspected. By letter dated November 18, 2010, the staff issued RAI B.2.1.17-1, asking the applicant to verify whether the Structures Monitoring Program would also include inspection of tank coatings for tanks 1-FP-TK-35-A, 1-FP-TK-35-B, 1-FP-TK-36-A, 1-FP-TK-36-B, and 1-FP-TK-29-A. In its response dated December 17, 2010, the applicant stated that, in addition to monitoring the aging effects in the tanks, the program would also include inspection of the external surfaces of the aboveground tanks for cracking, flaking, or peeling of paint or coatings. After further review of the applicant's response, it was still not clear how often the applicant plans to visually inspect the tanks for cracking, flaking, or peeling of paint or coating(s) and whether it intends to follow the Structures Monitoring Program or the Aboveground Steel Tanks Program guidance, which recommends visual inspections at least every 2 years. The staff addressed this concern in a teleconference with the applicant on March 18, 2011.

In a supplemental response provided by letter dated April 14, 2011, the applicant further clarified RAI B.2.1.17-1, stating that the Structures Monitoring Program will perform external visual or tactile (where required) surface inspections every 5 years of the aboveground steel tanks 1-FP-TK-35-A, 1-FP-TK-35-B, 1-FP-TK-36-A, 1-FP-TK-36-B, and 1-AB-TK-29 (fire fuel oil, fire water, and auxiliary boiler fuel oil tanks) to address cracking, flaking, or peeling of paint, coatings, sealants, and caulking. Additionally, the Fire Protection Program will visually inspect these tanks quarterly to assess the condition of their coatings. For tanks that have a caulking seal between the tank and the foundation, tactile examination will be performed to evaluate the condition of the caulking per the System Walkdown Engineering Guidelines.

The staff finds the applicant's response acceptable because the applicant will manage potential deterioration of the external surfaces of the aboveground tanks for cracking, flaking, or peeling of paint or coatings and, where applicable, the condition of caulking through two different AMPs—the Structures Monitoring Program and the Fire Protection Program. These two programs collectively will assure that the fire fuel oil tanks, fire water tanks, and auxiliary boiler fuel oil tanks external surfaces will be monitored so that the tanks can continue to perform adequately during the period of extended operation. The quarterly Fire Protection Program inspections also meet the frequency recommendation of every 2 years, as stated in the GALL Report AMP, Aboveground Steel Tanks Program. The staff's concerns described in RAI B.2.1.17-1 are resolved.

Enhancement 2. LRA Section B.2.1.31 states an enhancement to "parameters monitored or inspected" that expands the Structures Monitoring Program scope to include aging effects of elastomers for loss of sealing, leakage, and deterioration of seals; cracking of aluminum; abrasion and flaking of non-metallic fire proofing; corrosion, dirt, and distortion of Lubrite®; and degradation of below-grade concrete (the staff provides additional discussion on this enhancement later in this SER evaluation section, in reviewing the LRA amendments subsequent to the SER with open item issuance).

It was not clear to the staff, however, how the applicant will use visual inspections to detect degradations in elastomeric, aluminum, and non-metallic fire proofing materials before they lose their intended functions. The staff addressed this concern in a teleconference with the applicant on March 18, 2011.

In a supplemental response provided by letter dated April 14, 2011, the applicant stated that elastomeric roof material inspections will be done by a licensed professional roofing company. Every 5 years, the contractor will assess the condition of the roof elastomeric material for separation, environmental degradation, and water in-leakage due to weathering through physical roof walks and visual inspections. The applicant further stated that, for aluminum and non-metallic fire proofing materials, the applicant's inspectors are either licensed professional engineers experienced in this area or individuals working under the supervision of a licensed professional engineer with expertise in the design and inspection of steel, concrete, and masonry structures. During these inspections, aluminum will be visually inspected like all metallic materials (using the material aging effects) while non-metallic fire proofing, which is a sprayed on cementitious material, will be examined the same as concrete. The frequency of inspection is based on the environment, as articulated above. Harsh environments inspections will be performed every 5 years while those in mild environments will be every 10 years. The applicant, however, stated that operating experience may increase the frequency of these inspections. The applicant also stated that the acceptance criteria will be based on the engineering department standard for the Structures Monitoring Program, which describes the aging effects and evaluation criteria based on ACI 349 three-tiered hierarchy and quantitative limits. Finally, the applicant stated that upon further review of Table 3.5.2.4 in LRA Chapter 3, AMR item "Miscellaneous Yard Structures-Aluminum Station Blackout Structures Exposed To Air-Outdoor (External Weather)," was updated to reflect the appropriate aging effect for this component requiring management to be cracking instead of the originally reported crack initiation and crack growth.

The staff finds this enhancement and the clarifications provided by the applicant acceptable because inspections are performed periodically by professionals following the criteria laid out in the Structures Monitoring Program. Furthermore, when implemented, this enhancement will support the aging effects for the component types to be monitored during the period of extended operation and will provide criteria for inspection of seals, aluminum, non-metallic fire proofing, Lubrite®, and below-grade concrete. These enhancements of the "parameters monitored or inspected" program element of the applicant's Structures Monitoring Program are consistent with the "parameters monitored or inspected" program element provided in GALL Report AMP XI.S6, "Structures Monitoring Program."

Enhancement 3. LRA Section B.2.1.31 states an enhancement to the "monitoring and trending" program element that expands the Structures Monitoring Program to perform below-grade inspections of buried concrete at least once every 5 years through either an opportunistic or focused inspection.

The staff finds this enhancement acceptable because, when implemented, this enhancement will add clarification to the component types to be monitored during the period of extended operation so that the extent of degradation of the buried concrete is such that reasonable assurance is provided that these components are capable of fulfilling their intended functions. These enhancements of the "monitoring and trending" program element of the applicant's Structures Monitoring Program are consistent with the "parameters monitored or inspected" program element provided in GALL Report AMP XI.S6, "Structures Monitoring Program."

Enhancement 4. LRA Section B.2.1.31 states an enhancement to the "detection of aging effects" program element that expands the Structures Monitoring Program to include one-time UT examinations of the two fire protection water storage tanks prior to the period of extended operation.

The staff finds this enhancement acceptable because it supports the Aboveground Steel Tanks AMP, and the inclusion of the examinations under the Structures Monitoring Program procedures is acceptable. A review of the technical acceptability of the one-time UT examination and its comparison to the GALL Report Aboveground Steel Tanks Program recommendations is discussed in the staff's review of the Aboveground Steel Tanks Program in SER Section 3.0.3.2.9.

Based on its onsite audit, the staff finds that elements one through six of the applicant's Structures Monitoring Program, which integrates the Masonry Wall Program and the Water Control Structures Inspection Program, with acceptable enhancements, are consistent with the corresponding program elements of GALL Report AMPs XI.S5, XI.S6, and XI.S7. However, as discussed in the "Operating Experience" section below, the staff determined that the applicant needed to resolve Open Item OI 3.0.3.2.18-1 by enhancing program elements "parameters monitored or inspected," "detection of aging effects," "monitoring and trending," and "acceptance criteria," of the Structures Monitoring AMP to demonstrate that the effects due to ASR will be adequately managed during the period of extended operation.

By letter dated May 16, 2012, the applicant submitted a new plant-specific AMP (the ASR Monitoring Program), to demonstrate that cracking due to expansion from reaction with aggregates will be adequately managed during the period of extended operation. The staff evaluation of the ASR Monitoring Program is in Section 3.0.3.3.6. Additionally, by letter dated August 9, 2016, the applicant submitted an additional plant-specific aging management program (the Building Deformation Monitoring Program) to demonstrate that global effects of building deformation and macro cracking will be adequately managed during the PEO. The staff's review of the Building Deformation Monitoring Program is in SER Section 3.0.3.3.7.

Enhancement 1. LRA Section B.2.1.31 includes an enhancement to the "scope of program," "parameters monitored or inspected," and "monitoring and trending" program elements. In this enhancement, the applicant stated that it will expand the Structures Monitoring Program procedure to add the following:

(1) inspection of elastomeric materials for loss of sealing, leakage, and deterioration of CEVA seals; aluminum for cracking; non-metallic fireproofing for abrasion and flaking; and Lubrite® for distortion

(2) inspection of additional locations, including overhead and fuel handling cranes, NUREG-0612 cranes, all supports, tanks (1-FP-TK-35-A, 1-FP-TK-35-B, 1-FP-TK-36-A, 1-FP-TK-36-B, and 1-AB-TK-29) and their supports and foundations, fire house

boiler building, safety- and nonsafety-related electrical cable manhole and duct bank yard structures, and opportunistic or focused inspections of below-grade and inaccessible concrete at least once every five years

(3) ultrasonic testing and evaluation of the internal bottom surface of two fire protection water storage tanks

For part (1) of this enhancement, the staff finds the addition of the above-listed materials to the Structures Monitoring Program acceptable; however, the staff was not clear how visual inspections would detect degradation in elastomeric, aluminum, and non-metallic fire proofing materials before a loss of intended function.

By letter dated April 14, 2011, the applicant modified LRA Table 3.5.2.4 to state that elastomeric roof material inspections will be done by a licensed professional roofing company. Every five years, the contractor will assess the condition of the elastomeric roof material for separation, environmental degradation, and water in-leakage due to weathering through physical roof walks and visual inspections. The applicant further stated that, for aluminum and non-metallic fire proofing materials, the applicant's inspectors are either licensed professional engineers experienced in this area or individuals working under the supervision of a licensed professional engineer with expertise in the design and inspection of steel, concrete, and masonry structures. The applicant stated that, during these inspections, "aluminum will be visually inspected like all metallic materials (using the material aging effects) while non-metallic fire proofing, which is a sprayed on cementitious material, will be examined the same as concrete." The frequency of inspection is based on the environment. Harsh environments inspections will be performed every 5 years while those in mild environments will be every 10 years. The applicant stated that operating experience may increase the frequency of these inspections. The applicant also stated that "the acceptance criteria will be based on the engineering department standard for the Structures Monitoring Program, which describes the aging effects and evaluation criteria based on the ACI 349 three-tiered hierarchy and quantitative limits." Finally, the applicant stated that, upon further review of LRA Table 3.5.2.4, AMR item "Miscellaneous Yard Structures-Aluminum Station Blackout Structures Exposed To Air-Outdoor (External Weather)," was updated to reflect the appropriate aging effect for this component requiring management to be cracking instead of the originally reported crack initiation and crack growth.

The staff finds the clarifications provided by the applicant acceptable because inspections are performed periodically by professionals following the criteria laid out in the Structures Monitoring Program. The staff's concern regarding how visual inspections would detect degradation in elastomeric, aluminum, and non-metallic fire proofing materials before a loss of intended function is resolved.

For part (2) of this enhancement, the staff was not clear as to whether external coating inspections of tanks were included within the scope of the applicant's Structures Monitoring Program. Therefore, by letter dated November 18, 2010, the staff issued RAI B.2.1.17-1, asking the applicant to verify whether the Structures Monitoring Program would also include inspection of tank coatings for tanks 1-FP-TK-35-A, 1-FP-TK-35-B, 1-FP-TK-36-A, 1-FP-TK-36-B, and 1-AB-TK-29.

In its response dated December 17, 2010, the applicant stated that, in addition to monitoring the aging effects in the tanks, the program would include inspection of the external surfaces of the aboveground tanks for cracking, flaking, or peeling of paint or coatings. Upon review of the applicant's response, the staff was not clear as to the frequency for performing the visual inspection of these tanks. The staff needed additional information to determine whether the applicant intends to follow the Structures Monitoring Program or the Aboveground Steel Tanks Program guidance, which recommends visual inspections at least every 2 years.

By letter dated April 14, 2011, the applicant supplemented its response to RAI B.2.1.17-1. In its letter, the applicant further clarified its response to RAI B.2.1.17-1 by stating that the Structures Monitoring Program will perform external visual or tactile (where required) surface inspections every five years of the aboveground steel tanks 1-FP-TK-35-A, 1-FP-TK-35-B, 1-FP-TK-36-A, 1-FP-TK-36-B, and 1-AB-TK-29 (fire fuel oil, fire water, and auxiliary boiler fuel oil tanks) to address cracking, flaking, or peeling of paint, coatings, sealants, and caulking. Additionally, the Fire Protection Program will visually inspect these tanks quarterly to assess the condition of their coatings. For tanks that have a caulking seal between the tank and the foundation, tactile examination will be performed to evaluate the condition of the caulking per the System Walkdown Engineering Guidelines. In addition, as stated in its March 5, 2014, amendment to the Fire Water System Program, the external surfaces of the fire water storage tanks will be inspected on an annual basis in accordance with NFPA 25 (2011 Edition), Section 9.2.5.5.

The staff finds the applicant's response acceptable because the applicant will manage potential deterioration of the external surfaces of the aboveground tanks for cracking, flaking, or peeling of paint or coatings and, where applicable, the condition of caulking through three different AMPs—the Structures Monitoring, Fire Protection, and Fire Water System Programs. These programs collectively will ensure that the external surfaces of the fire fuel oil tanks, fire water tanks, and auxiliary boiler fuel oil tanks will be monitored so that the tanks can continue to perform adequately during the period of extended operation. The staff finds the 5-year interval for examination of the tanks under the Structures Monitoring Program acceptable because the tanks are also examined under the applicant's Fire Protection and Fire Water System Programs. The frequency of these inspections is consistent with GALL Report AMP XI.M26, Fire Protection Program, and GALL Report AMP XI.M27, Fire Water System Program, as modified by LR-ISG-2012-02. The staff finds the clarifications provided by the applicant acceptable because inspections are performed periodically by professionals following the criteria laid out in the Structures Monitoring Program. The staff's concerns described in RAI B.2.1.17-1 are resolved.

For part (2) of this enhancement, the staff noted that inclusion of opportunistic or focused inspections on a 5-year interval addresses GALL Report recommendations for examination of exposed portions of the below-grade concrete when excavated for any reason and development of a plant-specific AMP for plants with aggressive groundwater and soil that have experienced degradation. However, the staff also noted that the applicant inspected the remaining in-scope structures on a 5- or 10-year basis, depending on the structure's environment. The staff believes it may be acceptable to inspect structures on an interval greater than 5 years; however, the applicant must provide a list of the structures inspected under the longer interval, along with a description of their environments and justification for the interval extension. Therefore, by letter dated January 5, 2011, the staff issued RAI B.2.1.31-5, requesting that the applicant identify the structures that will be inspected on a 10-year frequency, along with their environments and a summary of past degradation.

In its response, dated February 3, 2011, the applicant stated that a harsh environment is an area routinely subjected to outside ambient conditions, high moisture or humidity, very high ambient temperatures or frequent large cycling of temperatures (including freezing and thawing), frequent exposure to caustic materials, or extremely high radiation levels. A mild environment is one that is not harsh. The applicant further stated that, based on ACI 349.3R, the evaluation and inspection frequency varies according to the environment, from 5–10 years. In accordance with ACI-349.3R, the interior, above-grade portions of the following in-scope of license renewal structures are in a mild environment and, therefore, subject to a 10-year inspection frequency:

- the containment enclosure ventilation area
- the control building
- the diesel generator building
- the waste process building and tank farm (selected areas are harsh)
- the emergency feedwater pumphouse building including pre-action valve building
- the fuel storage building
- the primary auxiliary building (selected areas are harsh)
- the turbine generator building
- the fire pumphouse
- the steam generator blowdown recovery building
- the non-essential switchgear building

The applicant also stated that it classified the following structures, following ACI-349.3R guidance, to be in a harsh environment and, therefore, subject to a 5-year inspection:

- all in-scope below-grade structures (interior and exterior)
- all exterior above grade structures
- all structures inside primary containment
- designated areas of the tank farm and of the primary auxiliary building
- the service water pumphouse
- the circulating water pumphouse
- the intake transition structure

- the discharge transition structure
- the service water cooling tower revetment

The applicant then reiterated that the past degradation of these structures is discussed in the body of the program in the LRA.

The staff reviewed the applicant's response and found that it needed clarification regarding (1) how frequently the spent fuel pool would be inspected and (2) whether the inspection frequencies outlined in the response applied to all structures within the scope of the Structures Monitoring Program or just concrete components. By letter dated May 10, 2012, the applicant confirmed that the spent fuel pool is an in-scope below-grade structure and would be inspected on a 5-year frequency and that the inspection frequencies outlined in the RAI response dated February 3, 2011, applied to all in-scope structures, regardless of the material. The staff finds the applicant's response acceptable because the applicant confirmed the spent fuel pool is an in-scope below-grade structure and would be inspected on a 5-year frequency, In addition, it outlined which structures are subject to a 5-year or 10-year inspection, and it aligned the frequency with that recommended in ACI-349.3R, which provides the basis for industry standards. Further, the applicant confirmed that the 5-year or 10-year inspection frequency based on ACI-349.3R applies to all structures within the scope of the Structures Monitoring Program. The staff's concern discussed in RAI B.2.1.31-5 is resolved.

For part (3) of this enhancement, the staff's review of the technical acceptability of the one-time UT examination and its comparison to the GALL Report Aboveground Steel Tanks Program recommendations is discussed in the staff's review of the Aboveground Steel Tanks Program in SER Section 3.0.3.2.9.

The staff finds this enhancement acceptable because, when implemented, this enhancement will (1) prescribe the parameters to be monitored for the component types to be inspected during the period of extended operation and will provide acceptance criteria for inspection of seals, aluminum, non-metallic fire proofing, and Lubrite®, (2) address the aging management of structures included within the scope of license renewal that are not covered by other structural AMPs, and (3) include one-time ultrasonic testing and evaluation of the internal bottom surface of the Fire Protection Storage tanks, consistent with the recommendations in GALL Report AMP XI.M29, "Aboveground Steel Tanks." This enhancement will make the Structures Monitoring Program consistent with the recommendations in the "scope of program," "parameters monitored or inspected," and "monitoring and trending" program elements of GALL Report AMP XI.S6.

Enhancement 2. LRA Section B.2.1.31 includes an enhancement to the "scope of program" and "parameters monitored or inspected" program elements. In this enhancement, the applicant stated that it will enhance its Structures Monitoring Program procedure to include opportunistic inspections when planning excavation work that would expose inaccessible concrete. Specifically, the applicant will enhance the "Dig Safe" procedure to include opportunistic inspection when planning excavation work. The staff finds this appropriate as it supports the program enhancement for the inspection of inaccessible, below-grade concrete due to aggressive groundwater inleakage. The staff finds this enhancement acceptable because, when implemented, this enhancement will ensure that opportunistic or focused inspections of normally inaccessible concrete are performed, when exposed during excavation work.

Based on its onsite audit, the staff finds that elements one through six of the applicant's Structures Monitoring Program, which integrates the Masonry Wall Program and the Inspection of Water-Control Structures Associated with Nuclear Power Plants Program, with acceptable enhancements, are consistent with the corresponding program elements of GALL Report AMPs XI.S5, XI.S6, and XI.S7. In addition, the staff reviewed the enhancements associated with "scope of program," "parameters monitored or inspected," and "monitoring and trending," program elements and finds that, when implemented, they will make the AMP adequate to manage the applicable aging effects.

Operating Experience. LRA Section B.2.1.31 summarizes operating experience related to the Structures Monitoring Program and states that groundwater infiltration through below-grade concrete structures has been an issue at Seabrook. Groundwater sampling performed in November 2008 and September 2009 found pH values between 6.01–7.51, chloride levels between 19–3,900 ppm, and sulfate levels between 10-100 ppm, indicating that the groundwater is an aggressive environment. The LRA also states that below-grade concrete structures have experienced groundwater infiltration through cracks, capillaries, pore spaces, seismic isolation joints, and construction joints. To stop or reduce the infiltration, various methods have been used but have had only limited success (e.g., dewatering wells and waterproofing agents). The LRA further states that additional testing is planned during the second and third quarters of 2010 in areas that experienced groundwater infiltration to determine its aging effects and the need for additional remedial action. The LRA finally states that visual inspections have been conducted of nonsafety-related masonry for indications of cracking and degradation as identified in the "monitoring checklist" of the applicant's Structures Monitoring Program. The condition of water control and flood protection structures has been assessed through visual inspections conducted through the applicant's Structures Monitoring Program.

The staff reviewed the operating experience information, in the application and during the onsite audit, to determine if the applicable aging effects and industry and plant-specific operating experience were reviewed by the applicant. As discussed in the audit report, the staff conducted an independent search of the plant operating experience information to determine if the applicant adequately incorporated and evaluated operating experience related to this program.

During its review, the staff identified operating experience that could indicate that the applicant's program may not be effective in adequately managing aging effects during the period of extended operation and needs to be modified to demonstrate that the effects of aging will be adequately managed. The staff determined the need for additional clarification that resulted in the issuance of four RAIs. These are discussed below.

RAI B.2.1.31-1. During the audit walkdown and review of condition reports, the staff noted that groundwater infiltration through below-grade concrete walls has been a chronic issue at the plant. The staff also observed indications of leaching and alkali-aggregate reactions occurring in the concrete exposed to groundwater infiltration. The staff was unclear if the concrete degradation due to groundwater infiltration had been quantified and how the degradation will be managed during the period of extended operation. To address the groundwater issue, by letter dated November 18, 2010, the staff issued RAI B.2.1.31-1, expressing concerns on the effects of infiltration in the concrete structures and requesting that the applicant provide a summary of all concrete mechanical testing performed to date and explain how its results are correlated to the actual plant structures. The staff also asked the applicant to provide the root cause of any reductions in structural capacities and degraded material properties and explain how the followup aging effects would be managed during the period of extended operation.

In its response dated December 17, 2010, the applicant stated that concrete mechanical testing, performed in May 2010, is only reflective of the location where it was conducted. Specifically, the applicant stated that cores were taken and penetration resistance tests (PRT) were conducted to evaluate the compressive strength of concrete, at elevation -20 ft of the "B" Electrical Tunnel. The average compressive strength for the PRT was 5,340 psi and, for the bores, 4,790 psi. The measured strength was approximately 20 percent less than that obtained in earlier years. In particular, the PRT performed in 1979 yielded a compressive strength of 6,759 psi. For the construction test cylinders tested in 1975, the compressive strength was 6,120 psi. Similarly, analysis of current data indicated a reduction in the original modulus of elasticity by about 47 percent. Further, petrographic analysis of the 2010 core samples showed evidence of ASR. The applicant further stated that a prompt operability determination concluded that the areas of concrete on the "B" electrical tunnel affected by ASR comply with the applicable design codes, and the structural integrity of the "B" electrical tunnel is intact with all SSCs housed within the tunnel being operable and capable of performing their design functions. The applicant finally stated that an extent of condition investigation is in progress to test potentially five additional suspect areas (including the containment enclosure building) to obtain supplementary information for the assessment of the plant concrete condition and the cause of its degradation. The Structures Monitoring Program has recognized ACI 349 as a monitoring and inspection standard that will help manage aging effects during the period of extended operation. Identified deficiencies will be evaluated and put into the corrective action program for resolution (i.e., remediation, corrective, and preventive actions) as required, including further structural analysis, if necessary.

After review of the applicant's response, the staff did not understand what the extent of condition assessment would include and how it would ensure the adequacy of susceptible concrete during the period of extended operation. The response also lacked information regarding approximate completion dates and a probable path forward including the location and timing of future tests and proposed remedial actions. Therefore, by letter dated March 17, 2011, the staff issued a followup RAI to RAI B.2.1.31-1, asking the applicant to identify the extent and timeliness of the assessment and anticipated remediation, including the path forward to ensure the concrete would retain its integrity during the period of extended operation.

By letter dated April 14, 2011, the applicant responded to the RAI. In the response, the applicant stated that concrete samples had been taken from five additional locations, which were chosen because they exhibited groundwater in-leakage and surface cracking indicative of ASR. The applicant further explained that an action plan was being developed to address the ASR degradation. The plan would include multiple activities to include those listed below:

- identify areas potentially susceptible to ASR
- complete concrete testing in other susceptible areas to determine compressive strength, modulus of elasticity, and confirm the presence of ASR
- based on test results, reconcile existing calculations and analyses to ensure structures continue to meet all design basis conditions
- perform lab tests to determine the rate of the ASR degradation mechanism and how it propagates
- issue an engineering evaluation addressing ASR, the results of testing, and mitigation techniques
- update the Structures Monitoring Program to include guidance on monitoring for ASR, including the appropriate frequency of inspection
- develop a long-range plan to implement mitigation techniques to arrest ASR degradation

The applicant further stated that the implementation of the action plan is tentatively scheduled to be completed in December 2013. Finally, the applicant stated that the Structures Monitoring Program will be revised to include action for inspection and monitoring of concrete for degradation due to ASR.

The staff reviewed the applicant's response and finds the response lacked specific information about what tests (laboratory and in-situ) would be conducted and when. The response also made no mention of how possible reductions in concrete shear strength were being estimated and addressed. In addition, the RAI response stated that cores were being taken in accordance with American Concrete Institute (ACI) 228.1R-03; however, it did not address the statistical validity and size of core samples taken or planned at each location. Therefore, by letter dated June 29, 2011, the staff issued follow up RAI B.2.1.31-1 requesting the applicant to:

(1) Explain if the current operability evaluation remains valid until the long-term aging management plan is developed and implemented.

(2) Explain how the concrete tests and evaluations performed so far can be used to establish a trend in degradation of the affected structures until the long-term aging management plan is implemented.

(3) Provide detailed and comprehensive information regarding the planned approach to addressing ASR degradation throughout the site.

(4) Explain how the possibility of a reduction in shear strength capacity due to ASR degradation is being evaluated.

By letter dated August 11, 2011, the applicant provided initial response to the RAI. In this response, the applicant stated that the current operability determination is expected to remain valid but may require modification. The applicant also stated that a comprehensive plan to evaluate and address ASR concrete degradation, and develop and implement a long-term monitoring plan is ongoing and will be included in an engineering evaluation scheduled to be completed by March 2012.

In a subsequent letter dated March 30, 2012, the applicant stated that it has initiated actions to perform additional testing to demonstrate that the effects of ASR on in-scope structures can be managed to maintain the intended functions of the affected structures through the period of extended operation. The applicant also stated that, through this testing, quantitative crack limits will be developed. The crack limits will be incorporated into the Structural Monitoring Program to manage the effects of ASR on concrete structures. The quantitative crack limits will be used to develop acceptance criteria such that corrective action can be implemented prior to loss of intended function. The applicant also submitted another letter on April 18, 2012, in which it stated that the two operability evaluations were revised on October 11, 2011. These revised operability evaluations concluded that the ASR affected structures are fully capable of performing their intended function and operable with reduced margin. The applicant further stated that full qualification will be attained when the testing and analysis plans are completed and the long-term resolution is incorporated into the UFSAR and/or other applicable design documents.

The staff reviewed the applicant's response in the three letters and noted that the applicant plans to enhance the Structural Monitoring Program to manage ASR degradation. However, the enhancements will not be completed until the long-term additional testing is completed and quantitative acceptance criteria for crack limits are developed. The staff was concerned that the applicant has not provided the details of the proposed enhancements to the program elements "parameters monitored or inspected," "detection of aging effects," "monitoring and trending," and "acceptance criteria," to the Structures Monitoring AMP to manage the effects of ASR. A revised aging management program with enhancements for managing the ASR degradation, for each in-scope concrete structure, is required to demonstrate that the effects of aging will be maintained consistent with the CLB for the period of extended operation as mandated by 10 CFR 54.21(a)(3). This issue was identified as Open Item OI 3.0.3.2.18-1 and has been resolved and closed based on the staff evaluations in SER Sections 3.0.3.3.6 and 3.0.3.3.7.

RAI B.2.1.31-2. During the audit walkdown and review of condition reports, the staff also noted that groundwater infiltration has caused degradation of internal plant structures and components, such as supports, base-plates, cable trays, etc. The staff was unclear how the degradation due to groundwater infiltration will be managed during the period of extended operation (i.e., concerned that the groundwater infiltration may be causing accelerated degradation of plant structures, supports, and components, as noted in the condition reports reviewed during the audit). Therefore, by letter dated November 18, 2010, the staff issued RAI B.2.1.31-2, asking the applicant to explain how internal plant structures exposed to groundwater infiltration will be managed for additional or accelerated degradation during the period of extended operation.

In its response, dated December 17, 2010, the applicant reiterated that components affected by groundwater in-leakage are managed through the plant's Structures Monitoring Program, which follows the Structural Engineering Standard Technical Procedure issued in March 2010. The Structures Monitoring Program inspects building structural steel components (e.g., base plates, columns, beams, braces, platforms, cable trays, structural bolting, and fasteners) for corrosion, peeling paint, excessive support deflections, twisting, warping, or locally deflecting beams and columns, loose or missing anchors and fasteners, missing, cracked, or degraded grout under the steel base plates, and cracked welds. The program evaluates and assesses each component's acceptability based on the extent of its degradations and then initiates corrective actions, followed by additional inspections to verify their effectiveness.

After review of the applicant's response, it was not clear to the staff why, after the update of the procedure in March 2010, there was still degradation due to in-leakage witnessed during audit walkdown in October 2010. To this end, by letter dated March 17, 2011, the staff issued a followup RAI to RAI B.2.1.31-2, asking the applicant to state what actions will be taken to avert further degradation in areas prone to groundwater in-leakage.

By letter dated April 14, 2011, the applicant responded to the RAI and stated that deficiencies identified in structural steel during structures monitoring inspections are documented in the inspection reports and evaluated. The applicant further stated that deficiencies that do not meet the acceptance criteria are entered into the corrective action program, and deficiencies that are accepted by engineering review are trended for evidence of further degradation. The applicant also explained that deficiencies being repaired or trended are subject to follow-up inspections at a maximum frequency of 2.5 years. The applicant also stated that the structures monitoring procedure has been revised to include specific direction regarding monitoring for the presence of water in-leakage.

The staff reviewed the applicant's response and finds it acceptable because the applicant explained that deficiencies are either repaired or accepted by engineering review. If a condition is accepted by engineering review, the inspection frequency is adjusted accordingly to provide assurance that any further degradation will be properly identified and addressed (e.g., maximum inspection frequency of 2.5 years). This approach is consistent with recommendations in the GALL Report AMP XI.S6 which recommends that aging effects are evaluated by qualified personnel using criteria derived from industry codes and standards contained in the plant current licensing bases, including ACI 349.3R. As recommended in ACI 349.3R, the applicant's inspectors for the Structures Monitoring Program are either licensed professional engineers or individuals working under the supervision of a licensed professional engineer with expertise in the design and inspection of steel, concrete, and masonry structures. These inspectors are qualified and will adjust the inspection frequency depending on the results of the inspection but not more than 2.5 years for structural steel components in the areas of ground water in-leakage. This is consistent with the guidance in ACI 349.3R that recommends increase in frequency of inspection for structures that are found to be degraded beyond acceptance criteria. The staff's concerns described in RAI B.2.1.31-2 and followup RAI are resolved.

RAI B.2.1.31-3. During the audit walkdown and review of condition reports, the staff further noted that groundwater infiltration through below-grade concrete walls has been a chronic issue at the plant; however, the staff was unable to locate any inspection reports that identified and monitored and trended the degradation caused by the infiltration in a quantitative manner. The staff concluded that a baseline quantitative concrete inspection of in-scope structures is necessary for monitoring and trending degradation during the period of extended operation. Therefore, by letter dated November 18, 2010, the staff issued RAI B.2.1.31-3, requesting that the applicant discuss plans for conducting a quantitative baseline inspection, in accordance with ACI 349.3R, prior to the period of extended operation.

In its response, dated December 17, 2010, the applicant stated that the Structures Monitoring Program described in LRA Appendix A, Section A.2.1.31, and LRA Appendix B, Section B.2.1.31, has been revised to include the ACI 349.3R guidance for inspections. This is reflected in Supplement 2 of the Seabrook LRA, dated November 15, 2010. The implementing procedure for the Structures Monitoring Program issued in March of 2010 describes the evaluation criteria based on the ACI 349.3R three-tiered hierarchy and quantitative limits.

The staff reviewed the applicant's response and finds it acceptable because the implementing procedure for the program, issued in March 2010, follows the industry-defined three-tiered ACI 349.3R hierarchical standard (i.e., acceptance without further evaluation, acceptance after review, conditions requiring further evaluation) with quantitative limits. In addition, the new acceptance criteria have already been implemented and are being used during current structural inspections. The staff's concerns described in RAI B.2.1.31-3 are resolved.

RAI B.2.1.31-4. During the audit and review of program basis documents, the staff noted that the fuel transfer canal has shown indications of borated water leakage. In order to complete its review, the staff requested additional information on historic and current leakages (values, paths, etc.) and the condition of the affected structures. Therefore, by letter dated November 18, 2010, the staff issued RAI B.2.1.31-4, requesting that the applicant discuss the leakage path, current status of leak(s), and any other information to demonstrate that the affected structures will be able to perform their intended functions during the period of extended operation.

In its response dated December 17, 2010, the applicant itemized historical records dating back to 1999. The response states that, during that year, the applicant performed a root cause investigation "to identify the source of water in the annulus between the containment building and the containment enclosure building." The applicant stated that as part of the investigation, a leak in the spent fuel pool was identified. The applicant stated that, immediately upon discovery, an enclosed tank was installed in the spent fuel pool leakoff sump to collect new leakage and to protect the sump and the environment from further contamination. Additional actions included protecting foundations and groundwater from contamination with selective dewatering through existing wells and removing leakage from contaminated systems. From 2000–2004, testing and inspection continued in the spent fuel pool, the spent fuel transfer canal, and the cask handling area to identify the source of the leak. In 2004, the applicant installed a nonmetallic liner in an attempt to stop the leakage. The applicant further stated that, by 2004, the leak had stopped in the spent fuel pool (confirmed by the lack of contaminated water in the sump), but water level fluctuations caused the leak in the canal to increase to 350 gallons per day. A 2002 and 2004 chemical analysis of leakage indicated that it is compatible to the water in the spent fuel pool. From 2005–2008, the applicant repaired delaminated liner (i.e., coatings) for the spent fuel pool, and since 2006, the applicant has instituted programmatic weekly monitoring of the leakage.

After review of the applicant's response, it was not clear to the staff whether the applicant has stopped all the leakage and that no through-wall leakage is occurring. In addition, based on industry operating experience with failures of spent fuel pool nonmetallic coatings, the staff is not confident that the nonmetallic liner is an appropriate long-term fix. To address these issues, by letter dated March 17, 2011, the staff issued a follow-up RAI to B.2.1.31-4, requesting that the applicant discuss the measures to be taken to demonstrate the integrity of the concrete structures exposed to spent fuel pool leakage, including the possibility of core bores from known leakage locations. The staff also requested that the applicant explain its conclusion that no through-wall leakage is occurring at the present, especially in inaccessible areas. Furthermore, the staff asked the applicant to demonstrate that, if a nonmetallic liner is relied upon to stop leakage, what measures will be taken to ensure its adequacy during the period of extended operation.

By letter dated April 14, 2011, the applicant responded to the RAI and stated that a core-bore test would be completed no later than December 31, 2015. The test would take place in an area subjected to wetting during the timeframe of the leakage and would test for the compressive strength of the concrete and would expose rebar for detection of any potential loss of material. The applicant further stated that the spent fuel pool leak-off system is routinely hydro-lazed to ensure that it is free-flowing. The applicant stated that the leak-off system is the path of least resistance for any water between the liner plate and the concrete wall, and leakage from the spent fuel pool would drain to the leak collection sump. The sump is periodically sampled and tested for signs of leakage, such as boron and tritium. Finally, the applicant stated that the nonmetallic lining is replaced on the basis of condition monitoring that will identify when the end of life for the material has been reached. The applicant stated that the following activities will be continued during the period of extended operation:

- monitoring of the liner coating coupon system under the Preventive Maintenance (PM), "Visual Inspection of Coupons Coated with SEFR"
- continued sampling and analysis of leak system effluent under procedure "Spent Fuel Pool Leakage Collection Program"

The staff reviewed the applicant's response but found the response was unclear in identifying where the leakage was coming from and what the leakage values had been historically. In addition, the applicant did not identify how frequently the leak-off system was confirmed to be clear. To clarify these points, the staff held a conference call with the applicant on May 31, 2011. During the conference call, the applicant stated that additional spent fuel pool leakage was detected during the spring 2011 outage. Therefore, to address this additional operating experience, by letter dated June 29, 2011, the staff issued followup RAI B.2.1.31-4 requesting that the applicant:

(1) Provide technical justification for the adequacy of the December 31, 2015, deadline for the spent fuel pool concrete core bore, or provide a new deadline and appropriate justification.

(2) Identify the frequency that the leak-off system is ensured to be free-flowing.

(3) Provide information on the recent leakage from the spent fuel pool, including the probable leakage path and source; whether the leakage is contained within the leak-off system; and whether or not chemical analysis will be performed on leakage during the period of extended operation.

By letter dated August 11, 2011, the applicant responded to the first request by stating that there is no continuous borated water leakage from the spent fuel pool. Currently, any leakage collects in a catch basin in sump and does not contact concrete. The applicant further committed to confirming the absence of embedded steel corrosion by performing a shallow core sample in an area subjected to wetting during the time frame of the spent fuel pool leakage. Finally, the applicant stated that the December 31, 2015, deadline was acceptable because similar operating experience at other nuclear plants has shown that structural capacity is not significantly affected by exposure to borated water.

In response to the second request, the applicant stated that hydro-lazing is performed on the spent fuel pool leak-off lines at a 4.5-year frequency, which will be maintained throughout the period of extended operation. The applicant also explained that leak-off is recorded once a month and reviewed by the system engineer. Unusual leakage, or lack thereof, could be an indicator of blockage and would be investigated accordingly.

In response to the third request, the applicant stated that the spent fuel pool leak-off is analyzed for gamma and tritium activity. On April 6, 2011, zone 6 of the spent fuel pool leak-off system showed a step increase in the tritium activity concentration. The applicant explained that this increase occurred coincident with refilling of the cask loading pool, which had previously been drained. At this point, the leak rate was estimated at 1.2 gal per day (gpd). Subsequent measurements identified a peak leak rate of approximately 2.57 gpd, which decreased to the current level of 0.016 gpd (approximately 2 oz per day). The applicant further explained that, on average, approximately 10 gpd of groundwater infiltration leaks out of the zone 6 tell-tale line. The applicant explained that "[t]he volume of spent fuel pool leakage is estimated by taking the ratio of the leak-off line tritium concentration to the pool tritium concentration and multiplying that value by the amount of zone 6 leakage pumped out from the collection tank. In this particular instance, the only leak-off line that indicated any leakage was zone 6." The applicant then stated that there are several potential causes for the increased leakage, including a new stainless steel liner plate leak in an area not coated with the non-metallic liner; a failure in the non-metallic liner at the same location as a stainless steel liner failure; or a skimmer pit leak. The applicant further stated that these possibilities are being addressed with corrective actions, including verifying the integrity of the cask loading area liner through drain down and inspection, revising procedures for cask filling to limit the pool level, and determining if the current design of the skimmer pits is appropriate or if changes can be made to prevent leakage from the pit. Finally, the applicant committed to analyze spent fuel pool leak-off for chlorides, sulfates, pH, and iron for four quarters of 1 year once every 5 years.

The staff reviewed the applicant's response and was unable to determine the source or flow path of the leakage. In response to the first portion of the followup RAI, the applicant stated that it "does not have continuous borated water leakage from the spent fuel pool"; however, in response to the third portion, the applicant stated "leakage decreased to the current level of 0.016 gpd." Based on this response, it is not clear if the spent fuel pool is leaking. The staff also noted that the applicant committed to monitor the leakage quarterly for chlorides, sulfates, pH, and iron once every 5 years (Commitment No. 68). This approach is unacceptable (i.e., may not be adequate) for detecting a possible trend that could indicate degradation such as an increase in the iron content of the leakage. The staff provided its concerns to the applicant during an inspection visit the week of September 26, 2011.

To address these concerns, the applicant supplemented its response to followup RAI B.2.1.31-4 by letter dated November 2, 2011. In its response, the applicant explained that the spent fuel pool, cask handling, and fuel transfer canal areas have nine zones that collect leakage. The spent fuel pool is separated from the cask handling area and the fuel transfer area by a gate.

The applicant stated that there have been no incidents of leakage from the spent fuel pool; the only incidents of leakage have been from the cask handling and fuel transfer canal areas. The applicant further stated that zone 6 is the only leakage collection sample line that routinely has water flow, that this zone collects leakage from the cask handling area, and that the majority of the water in the zone 6 sample line is from groundwater in-leakage. The applicant further clarified that the leakage detected on April 6, 2011, was from zone 6, which meant it was from the cask handling area and not the spent fuel pool. The applicant also updated Commitment No. 68 to sample the leak-off water once every 3 months.

The staff reviewed the applicant's supplement and noted that leakage has not occurred from the spent fuel pool; all historic leakage has been from the cask handling and fuel transfer canal areas. The staff also noted that the applicant plans to sample the leak-off water quarterly, which provides reasonable assurance any negative trends in chlorides, sulfates, pH, or iron content that could indicate degradation would be captured in a timely fashion. The staff also reviewed the original RAI and followups dated December 17, 2010, April 14, 2011, and August 11, 2011, and noted that the current leakage is captured within the leak-off system and is collected in the spent fuel pool leakage sump. The staff further noted that there has been no operating experience with leakage migrating through the concrete walls, except the leakage identified in 1999, which was leakage out of the sump that had been directed to the sump by the leak-off collection system. Once the spent fuel pool leakage sump was identified as the source of the through-wall leakage, a tank was added to the sump, which collects any leak-off flow before it potentially contaminates the sump. The staff also noted that, in order to keep the leak-off system free-flowing, the applicant will hydro-laze the lines on a 4.5-year frequency and monitor the flow monthly for any indications of blockage. Finally, the staff noted that the applicant committed to take a core bore from the spent fuel pool sump in an area that was exposed to through-wall leakage (Commitment No. 67). The bore will be examined for concrete degradation and will expose the rebar to examine it for any signs of degradation. Based on its review, the staff finds the applicant's response and approach acceptable for the following reasons:

- The applicant has plans in place to take a core bore from an area that was continuously wetted by borated water. This provides assurance that any degradation that may have occurred in the past will be identified and addressed prior to the period of extended operation.
- The applicant does not currently have any indications of leakage migrating through the concrete walls of the spent fuel pool (i.e., leakage not captured in the leak-off system). This provides assurance that any degradation that may have occurred in the past due to borated water will not continue during the period of extended operation.
- The applicant has plans in place to maintain the leak-off system clear of blockage, which provides assurance that any future leakage will be captured in the system and directed to the sump, as opposed to migrating through the spent fuel pool concrete walls.
- The applicant will monitor the chemical properties of the leak-off collection on a quarterly basis. Any changes in the chemical makeup of the leak-off water could be a sign that the leakage is interacting with the concrete, which may indicate leakage outside of the collection system.
- The applicant will continue to attempt to locate the leakage source and stop it completely.

Based on the above, the staff's concern discussed in RAI B.2.1.31-4, and the associated followup RAIs, is resolved. By letter dated January 29, 2016 (ADAMS Accession No. ML16035A245), the applicant provided the status of several commitments, including Commitments 67 and 68 related to the spent fuel pool leakage. The letter noted that a core had been taken in accordance with Commitment No. 67 and that no degradation from boric acid exposure was identified in the concrete or the exposed rebar. The core did show early indications of ASR progression. The letter also noted that a routine preventative maintenance activity was established and started as of January 29, 2014, to conduct quarterly leak-off collections and chemical testing from the spent fuel pool, thereby meeting the intent of Commitment 68.

The staff reviewed the provided information related to Commitments 67 and 68. Commitment 67 confirmed that the borated water leakage was not having a structural impact on the spent fuel pool. Although indications of ASR degradation were identified, this will be addressed within the plant-specific ASR Monitoring Program. Commitment 68 began tracking the chemical composition of the spent fuel pool leakage and any significant changes will be addressed within the applicant's corrective action program. Significant changes in chemical makeup of the leakage could indicate additional interaction with the concrete or reinforcement, or possibly leakage from a different source. Based on its review, the staff finds that the applicant adequately completed Commitments 67 and 68.

Alkali-Silica Reaction (ASR). In its June 8, 2012, Safety Evaluation Report with Open Items, the staff identified that management of expansion due to reaction with aggregates (ASR) had not been sufficiently addressed by the applicant and concluded that that ASR issue was an open item. Following initially proposing to manage cracking due to expansion from reaction with aggregates using the Structures Monitoring Program and ASME Section XI, Subsection IWL Program, the applicant subsequently developed plant-specific aging management programs to manage the effects ASR on concrete structures. On May 16, 2012, the applicant submitted its plant-specific ASR Monitoring Program. The applicant stated that the ASR Monitoring Program will be used to manage the effects of ASR microcracking. On August 9, 2016, the applicant submitted an additional plant-specific Building Deformation Monitoring Program to address building deformation and macro cracking due to ASR. The history of the ASR issue, a summary of the staff's RAIs and the applicant's responses, and the staff's evaluation of the applicant's ASR Monitoring Program are in SER Section 3.0.3.3.6. The staff's evaluation of the Building Deformation Monitoring Program are in SER Section 3.0.3.3.7.

Based on its audit and review of the application, and review of the applicant's responses to RAIs B.2.1.31-2, B.2.31-3, B.2.1.31-4, associated follow up RAIs listed in SER Sections 3.0.3.3.6 and 3.0.3.3.7, and the augmentation of the Structures Monitoring Program and the ASME Section XI, Subsection IWL Program with the ASR Monitoring Program and Building Deformation Monitoring Program, the staff finds that the applicant has appropriately evaluated plant-specific and industry operating experience, and implementation of the program has resulted in the applicant taking corrective actions. Based on the staff evaluations documented in SER Sections 3.0.3.3.6 and 3.0.3.3.7, Open Item OI 3.0.3.2.18-1 related to managing aging effects due to ASR is closed.

<u>UFSAR Supplement</u>. LRA Section A.2.1.31 provides the UFSAR supplement for the Structures Monitoring Program.

- In LRA Appendix A, the applicant provided the UFSAR supplement for the Structures Monitoring Program. The staff reviewed this UFSAR supplement and noted that it is consistent with the recommended description in SRP-LR Table 3.5-2. However, the supplement made no mention of ACI 349.3R, which is an important reference document for the applicant's program. Several of the applicant's program elements were found consistent with the GALL Report recommendations because they followed guidance from ACI 349.3R. This concern was provided to the applicant during the October 2012 audit. By letter dated November 15, 2010, the applicant revised the UFSAR supplement to include ACI 349.3R. The staff also noted that the applicant committed (Commitment Nos. 32 and 33) to enhance the Structures Monitoring Program prior to entering the period of extended operation. Specifically, the applicant committed to do the following:enhance the procedure to add the aging effects, additional locations, inspection frequency, and ultrasonic test requirements
- enhance the procedure to include inspection of opportunity when planning excavation work that would expose inaccessible concrete

In addition, the applicant committed (Commitment Nos. 67 and 68) to do the following:

- perform one shallow core bore in an area that was continuously wetted from borated water to be examined for concrete degradation and also exposed rebar to detect any degradation such as loss of material, no later than December 31, 2015.

- perform sampling at the leakoff collection points for chlorides, sulfates, pH, and iron once every 3 months, starting in January 2014

The staff notes that subsequent to the issuance of the SER with Open Items, commitments 67 and 68 were completed as previously indicated in this SER section. The staff finds that, the information in the UFSAR supplement, as amended, is an adequate summary description of the program.

Conclusion. On the basis of its audit and review of the applicant's Structures Monitoring Program, the staff determines that those program elements for which the applicant claimed consistency with the GALL Report are consistent. Also, the staff reviewed the enhancements and confirmed that their implementation prior to the period of extended operation will make the AMP adequate to manage the applicable aging effects. The ASR Monitoring Program and the Building Deformation Monitoring Program which are augmentations of the SMP and ASME Section XI, Subsection IWL Program are documented in SER Section 3.0.3.3.6 and 3.0.3.3.7, based on which Open Item OI 3.0.3.2.18-1 is resolved and closed. The staff concludes that the applicant has demonstrated that the effects of aging will be adequately managed so that the intended function(s) will be maintained consistent with the CLB for the period of extended operation, as required by 10 CFR 54.21(a)(3). The staff also reviewed the USAR supplement, as amended, for this AMP and concludes that it provides an adequate summary description of the program, as required by 10 CFR 54.21(d).

3.0.3.3.6 Alkali-Silica Reaction Monitoring Program

Summary of Technical Information in the Application. By letter dated May 16, 2012, the applicant submitted a new plant-specific aging management program, the Alkali-Silica Reaction Monitoring Program (ASRMR), to demonstrate that cracking due to expansion from reaction with aggregates will be adequately managed during the period of extended operation. As part of its investigation into why ASR occurred at Seabrook, the applicant conducted a root cause evaluation, which determined that "the concrete mix designs unknowingly utilized an aggregate that was susceptible to ASR." The applicant determined that the aggregate used was slow reactive, even though aggregate reactivity testing was conducted at the time of plant construction in accordance with ASTM C289, "Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)," and did not detect reactivity. The ASTM C289 standard was subsequently revised to caution that the testing was limited in its ability to identify slow- or late-reacting aggregates.

Information regarding the applicant's actions to address the ASR issue at Seabrook under its current operating license, including operability assessments, response to confirmatory action letter CAL 2012-002, and semi-annual review of ASR monitoring are discussed in a series of NRC Inspection Reports (05000443/2011002, 05000443/2011007, 05000443/2011003, 05000443/2011010, 05000443/2012009, 05000443/2012010, 05000443/2013005, 05000443/2014002, 05000443/2014003, 05000443/2014005, 05000443/2015002, 05000443/2015004, 05000443/2016008, 05000443/2016002, 05000443/2016004, and 05000443/2017004) and the related license amendment request (LAR) 16-03 dated August 1, 2016, and LAR Supplement dated September 30, 2016. This LAR amends the CLB for evaluating ASR-affected structures at Seabrook and also forms a technical basis for the ASR-related AMPs for license renewal. This SER section focuses on the staff's evaluation of aging management aspects of ASR degradation for the period of extended operation as part of the staff's review of the license renewal application (LRA); the staff's review of the adequacy of the technical bases supporting the AMP that are also applicable to the current licensing basis are documented in the staff's Safety Evaluation (SE) related to LAR 16-03.

LRA Section B.2.1.31A describes the ASR Monitoring Program as a plant-specific condition monitoring program. The LRA indicates that the existing Structures Monitoring Program, B.2.1.31, and ASME Section XI, Subsection IWL Program, B.2.1.28, have been augmented by this program, which is structured according to the guidance in ACI 349.3R, "Evaluation of Existing Nuclear Safety-Related Concrete Structures." The LRA states that the AMP addresses concrete structures that are exposed to air outdoor (external), raw water (external), air indoor uncontrolled (external), and soil (external), and proposes to manage cracking due to expansion from reaction with aggregates. The LRA also states that the AMP proposes to manage this aging effect through the performance of periodic visual inspections for indications of ASR and monitoring of the combined cracking index (CCI), individual crack widths, through-wall expansions, and volumetric expansion for locations that meet the criteria prescribed in the program.

The May 16, 2012, LRA Section B.2.1.31A was subsequently revised by letters dated September 13, 2013; May 15, 2014; November 21, 2014; June 30, 2015; December 3, 2015; August 9, 2016; October 3, 2017; November 3, 2017; and May 18, 2018.

The June 30, 2015, submittal indicated that building deformation had been observed in Seabrook structures. The submittal dated December 3, 2015, revised LRA Sections to discuss this aging effect and subsequent submittals discuss the applicant's approach to managing building deformation due to ASR with a Building Deformation Monitoring Program (BDMP). The staff's review of the plant-specific BDMP is documented in Section 3.0.3.3.7 of this SER.

The LRA describes the mechanism of ASR degradation, and describes a large-scale testing program (LSTP) conducted by the applicant to research the effects of ASR on structural capacity for certain limit states for which knowledge gaps existed in the literature. The LRA states that the structural assessment of ASR-affected structures considered the various limit states for reinforced concrete and applied available literature data to evaluate structural capacity. The applicant identified that there was limited available data for shear capacity and reinforcement anchorage for ASR-affected reinforced concrete with two-dimensional reinforcement mats, and the data that existed was not representative of Seabrook structures. The applicant stated that (1) the data for reinforcement anchorage were from a test method that ACI indicated is unrealistic; (2) literature data for shear capacity were from test specimens that were inches in size compared to the large structures at Seabrook; and (3) no data were available for anchor bolt capacity for concrete similar to Seabrook two-way reinforced structures. Therefore, the applicant opted to perform testing for these limit states. The staff notes that a sufficiently detailed description of the applicant's evaluations of structural limit states and design considerations is contained in Report MPR-4288, Revision 0, "Seabrook Station: Impact of Alkali-Silica Reaction on the Structural Design Evaluations," (ML16216A241) which was submitted to the NRC with LAR 16-03. The testing program, which was completed in early 2016, is credited as the technical basis supporting several aspects of the ASRMP and the conclusions of the test program underlie the BDMP structural evaluations. The test report summary, labeled as Report MPR 4273, "Seabrook Station – Implication of Large-Scale Test Program Results on Reinforced Concrete Affected by ASR," March 2018 (Seabrook FP# 101050) was submitted by letter dated May 18, 2018. The staff's evaluation of the LSTP and associated bases is discussed in the SE related to LAR 16-03 (ML18204A282 proprietary; ML18204A291 non-proprietary).

Staff Evaluation. In support of its review of the ASR Monitoring Program, the NRC staff conducted several onsite audits. During its audits the staff reviewed the applicant's ASR Monitoring Program against the requirements of 10 CFR Part 54; the guidance provided in SRP-LR Appendix A.1, "Aging Management Review—Generic"; and the GALL Report Revision 2 to verify that the AMP will adequately manage the effects of aging for structures affected by ASR. The table below lists the audit dates, locations, and documentation:

Dates of Audit	Location	Audit Report ML
November 10-13, 2013	Seabrook Station	ML13354B785
October 27-29, 2015	Ferguson Structural Engineering Laboratory, University of Texas at Austin	ML15307A022 (letter) ML15337A047 (report)
October 25-27, 2016	Seabrook Station	ML16333A247
March 19-22, 2018	Seabrook Station	ML18135A046

During its review, the staff required a number of Requests for Additional Information (RAIs) to address its concerns related to the applicant's proposal to manage the effects of ASR on structure intended functions. As the applicant continued to evaluate the staff's concerns, there were several revisions to the ASR Monitoring Program; Structures Monitoring Program; and ASME Section XI, Subsection IWL Program. The staff's evaluation of the Structures Monitoring Program and ASME Section XI, Subsection IWL Program are documented in SER Sections 3.0.3.2.18 and 3.0.3.2.17, respectively. However, since the ASR Monitoring Program includes all Seabrook concrete structures in the scope of license renewal, including primary containment, the staff's review of the applicant's program for managing the effects of ASR (including ASR-related correspondence that occurred prior to the applicant submitting the plant-specific ASR Monitoring Program) is primarily discussed in this section. Unless otherwise noted, the staff's evaluation relates to the latest version of the ASR Monitoring Program. Previous versions of the AMP and prior RAIs are only discussed as necessary to support the staff's conclusions. The RAIs and the responses are discussed briefly below, followed by the staff's evaluation of each of the program elements in the latest version of the ASR Monitoring Program (dated May 18, 2018). This section includes a summary of public meetings that occurred between the applicant and the staff throughout the review period and also notes when supplements were submitted.

- RAIs B.2.1.28-3 and B.2.1.31-1, issued by letter dated November 18, 2010: RAI B.2.1.28-3 requested details regarding the potential presence of ASR on the containment building due to the accumulation of water in the annulus area between the containment and containment enclosure building. RAI B.2.1.31-1 requested information regarding the results of concrete tests and plans to manage the effects of aging.

- RAI B.2.1.28-3 and B.2.1.31-1 responses provided by letter dated December 17, 2010: The applicant provided information regarding containment inspections (RAI B.2.1.28-3 response) and a summary of concrete testing results and indicated that an extent of condition investigation was initiated and that the Structures Monitoring Program would manage the effects of aging (RAI B.2.1.31-1 response). The letter included Commitment No. 51 (subsequently withdrawn by letter dated August 11, 2011) to perform confirmatory testing and evaluation of the containment building, and Commitment No. 52 to implement measures to maintain the annulus (i.e., the exterior surface of the Containment Structure, from elevation -30 ft to +20 ft) in a dewatered state.

- Followup RAI B.2.1.31-1, issued by letter dated March 17, 2011: Followup RAI B.2.1.31-1 requested additional information regarding the “extent of condition” investigation, including a discussion of planned tests, estimated timeframe, and plan to address ASR.

- Followup RAI B.2.1.31-1 response provided by letter dated April 14, 2011: The applicant indicated that the “extent of condition” was scheduled to be completed in June 2011 and provided high-level information regarding its action plan to address ASR.

- Followup RAIs B.2.1.28-3 and B.2.1.31-1, issued by letter dated June 29, 2011: Followup RAI B.2.1.28-3 requested clarification as to whether Commitment No. 51 remains valid and details for plans to monitor cracking due to expansion from reaction with aggregates on the containment building. Followup RAI B.2.1.31-1 requested detailed and comprehensive information regarding the applicant’s planned approach to addressing ASR throughout the site.

- Followup RAI B.2.1.28-3 and B.2.1.31-1 responses provided by letter dated August 11, 2011: The applicant indicated that confirmatory testing on the containment building cannot be made until the aging effects are fully understood (Followup RAI B.2.1.28-3 response) and that detailed information regarding the planned approach to addressing ASR throughout the site will be included in an engineering evaluation scheduled to be completed in March 2012 (Followup RAI B.2.1.28-3 and B.2.1.31-1 responses).

- Followup RAI B.2.1.31-1 response and supplemental responses to RAIs B.2.1.28-3, B.2.1.31-1, provided by letter dated March 30, 2012: The applicant indicated that a walkdown had been performed to assess the accessible portion of concrete structures and that it had “initiated actions to perform testing on full-scale replicas of station structural configurations” (Followup RAI B.2.1.31-1 response). The applicant also indicated that, based on inspections of the containment building in September 2011, two locations exhibiting pattern cracking will be monitored in Tier 2 (2nd of three “Tiers” of ASR cracking severity) of the Structures Monitoring Program (RAI B.2.1.28-3 supplemental response). Based on ongoing tests and analyses, supplemental responses were provided for RAI B.2.1.31-1 and Followup RAI B.2.1.31-1 to include the most current information.

- Plant-Specific ASR Monitoring Program provided as a supplement to the LRA by letter dated May 16, 2012: This supplement provided the initial plant-specific AMP, augmenting the Structures Monitoring Program, to address cracking due to expansion from reaction with aggregates.

- Followup RAIs B.2.1.28-3 and B.2.1.31-1, and RAIs B.2.1.31-5, -6, -7, -8, -9, -10, and -11, issued by letter dated September 14, 2012: Followup RAI B.2.1.28-3 requested clarifying information regarding the aging management of cracking due to expansion from reaction with aggregates for the containment building. Followup RAI B.2.1.31-1 requested clarifying information regarding the parameters monitored or inspected and acceptance criteria for the ASR Monitoring Program. RAI B.2.1.31-5 requested clarification as to whether visual inspections would be used to rule out the presence of ASR in a concrete structure. RAI B.2.1.31-6 requested the technical basis for the acceptance criteria proposed. RAI B.2.1.31-7 requested information to determine if monitoring was being proposed for a sample of the population meeting the acceptance criteria. RAI B.2.1.31-8 requested plans for the inspection of rebar, anchor bolts, and embedments. RAI B.2.1.31-9 requested information regarding the inspection of inaccessible areas. RAI B.2.1.31-10 requested clarification as to whether preventive or mitigative actions would be taken. RAI B.2.1.31-11 requested clarification on the scope of the Structures Monitoring Program.

- Followup RAI B.2.1.28-3 and B.2.1.31-1, and RAIs B.2.1.31-5, -6, -7, -8, -9, -10, and -11 responses provided by letter dated November 2, 2012: The applicant explained that the containment building is within the scope of the ASR Monitoring Program and areas exhibiting characteristics of ASR will be monitored accordingly (Followup RAI B.2.1.28-3 response). The applicant also explained that the parameters monitored are intended to monitor and trend cracking due to expansion from reaction with aggregates and that the acceptance criteria to be followed is that in the ASR Monitoring Program (Followup RAI B.2.1.31-1 response). The applicant further explained that visual inspection will not be used to rule out the presence of ASR (RAI B.2.1.31-5 response) and that the technical basis for the acceptance criteria was derived from three publications (RAI B.2.1.31-6 response). The applicant provided information regarding the inspection of rebar, anchor bolts, and embedments (RAI B.2.1.31-8 response) and the inspection of inaccessible areas of concrete (RAI B.2.1.31-9 response). The applicant indicated that preventive action or mitigative measures will not be relied upon for aging management (RAI B.2.1.31-10 response) and that the scope of the ASR Monitoring Program includes all concrete structures within the scope of license renewal (RAI B.2.1.31-11 response).
- Supplemental response to Followup RAI B.2.1.31-1 provided by letter dated November 20, 2012: The applicant revised the response to Followup RAI B.2.1.31-1 to explain that the results of the full-scale testing will be used in structural evaluations and that, in the event the results indicate the need to amend the acceptance criteria or inspection frequency, action will be taken under the "operating experience" program element.
- Supplement to the ASR Monitoring Program provided by letter dated September 13, 2013: The applicant supplemented the ASR Monitoring Program and UFSAR supplement to address the staff's concerns, expressed during a February 21, 2013, public meeting held to discuss the additional information needs of the staff.
- RAIs B.2.1.31A-1, -2, -3, -4, -5, and -6, issued by letter dated January 15, 2014: RAI B.2.1.31A-1 requested clarification regarding the ASR Monitoring Program augmentation of the ASME Section XI, Subsection IWL Program. RAI B.2.1.31A-2 requested information regarding the number of locations being monitored and the basis for frequency of inspection. RAI B.2.1.31A-3 requested clarification as to the timing of the transition (when) of Tier 2 locations from "qualitative monitoring" to "quantitative monitoring." RAI B.2.1.31A-4 requested information regarding the role of large-scale testing with respect to the AMP. RAI B.2.1.31A-5 requested an explanation as to how monitoring surface cracks is sufficient to monitor progression of ASR. RAI B.2.1.31A-6 requested additional information regarding the inspection of inaccessible areas of concrete structures.
- RAI B.2.1.31A-1, -2, -3, -4, -5, and -6 responses provided by letter dated May 15, 2014: The applicant revised the ASR Monitoring Program to indicate that it also augments the ASME Section XI, Subsection IWL Program (RAI B.2.1.31A-1 response). The applicant explained that all locations meeting Tier 2 or Tier 3 criteria will be monitored at the specified interval and provided the basis for the frequency of inspection (RAI B.2.1.31A-2 response). The applicant provided information regarding the transition between qualitative monitoring and quantitative monitoring (RAI B.2.1.31A-3 response) and revised the UFSAR to clarify the role of large-scale testing (RAI B.2.1.31A-4). The applicant committed (Commitment No. 83) to installing instrumentation (i.e., extensometers) in sample areas to determine if monitoring expansion in the out-of-plane direction is necessary (RAI B.2.1.31A-5 response), explained that the ASR Monitoring Program will be used to monitor inaccessible areas meeting the criteria, and revised Commitment No. 67 to indicate that the core being removed from the spent fuel pool (inaccessible area that was continuously wetted from borated water) will be examined for the presence of ASR (RAI B.2.1.31A-6 response).
- Supplemental response to RAI B.2.1.31A- provided by letter dated November 21, 2014: The applicant clarified its response to RAI B.2.1.31A based on discussions during a September 30, 2014, teleconference with the staff.
- RAIs B.2.1.31A-2(a), -5(a), and -6(a), and RAI B.2.1.31A-7, issued by letter dated November 25, 2014: RAI B.2.1.31A-2(a) requested clarification as to whether monitoring and trending results would be used to adjust the frequency of inspection such that it would exceed the 5-year inspection interval accepted for concrete inspections per ACI 349.3R. RAI B.2.1.31A-5(a) expressed the staff's concerns regarding the adequacy of four of the AMP program elements and requested that the applicant provide sufficient information to address the staff's concerns. RAI B.2.1.31A-6(a) requested information as to whether actions will be taken to confirm that the magnitude of cracking in inaccessible areas is not greater than that observed on accessible surfaces. RAI B.2.1.31A-7 requested clarification as to whether there are structures monitored on a 10-year inspection interval, as opposed to a 5-year interval, and justification for whether the 10-year interval will be adequate for identifying new areas affected by ASR.

- RAI B.2.1.31A-2(a) and B.2.1.31A-7 responses provided by letter dated February 23, 2015: In the RAI B.2.1.31A-2(a) response, the applicant explained that inspection frequencies of Tier 3 and Tier 2 areas currently specified in the ASR Monitoring Program may change, based on trending; however, the inspection frequencies will not exceed the 5-year frequency specified in the Structures Monitoring Program for areas in a harsh environment. In the RAI B.2.1.31A-7 response the applicant provided the Structures Monitoring Program definitions of a "harsh environment" and a "mild environment." Based on the definitions, the applicant explained that ASR is not expected and has not been detected in a "mild environment," because it lacks sufficient moisture to produce ASR. The applicant also explained that structures in a harsh environment are inspected on a 5-year interval and those in a mild environment, in which conditions favorable for ASR are not present, are inspected on a 10-year interval.

- RAI B.2.1.31A-5(a) and B.2.1.31A-6(a) responses provided by letter dated June 30, 2015 (ML15183A023): Response to RAI B.2.1.31A-5(a) regarding the use of large-scale testing data to inform monitoring methods and locations at Seabrook. Specifically, the response provided the technical basis for using combined cracking index for in-plane (x-y direction) expansion and extensometers for out-of-plane (through thickness or z direction) expansion. Commitment 83 was updated to include measurement of out-of-plane expansion with extensometers and Commitment 91 was added to address monitoring building displacements. In the response to RAI B.2.1.31A-6(a) the applicant stated that it will perform opportunistic or focused inspections of inaccessible concrete to ensure the extent of ASR degradation is bounded by inspection results from accessible concrete. This submittal also included MPR-4153, "Seabrook Station Approach for Estimating Through-Thickness Expansion from Alkali-Silica Reaction" (ML15183A020).

- RAI B.2.1.31A-8, B.2.1.31A-5(a1) to -5(a4), issued by Letter dated October 2, 2015 (ML15251A333): RAI B.2.1.31A-8 requested that the applicant address operating experience of building deformation and large macro cracking. RAI B.2.1.31A-5(a1) requested that the applicant justify the representativeness of the large-scale testing program to Seabrook structures. RAI B.2.1.31A-5(a2) requested that the applicant provide information related to uncertainties in the estimate of normalized modulus of elasticity used in MPR-4153. RAI B.2.1.31A-5(a3) requested information to justify the number of through-wall extensometer locations proposed for monitoring. RAI B.2.1.31A-5(a4) requested that the applicant provide details on the specifics of how the CCI would be used to monitor degradation and how it would account for strain in the concrete and rebar.

- Responses to RAI B.2.1.31A-8, B.2.1.31A-5(a1) to -5(a4) provided by letter dated December 3, 2015 (ML15343A470): In response to RAI B.2.1.31A-8 the applicant added building deformation operating experience to its ASR Monitoring AMP and reflected such in revised Commitment 91. In response to RAI B.2.1.31A-5(a1) the applicant provided specific information in relation to its testing programs related to methodology and intent of the testing, as well as how the data will apply to Seabrook. In response to RAI B.2.1.31A-5(a2) the applicant further discussed its methodology for estimation of through-wall expansion to date. It also alluded to a Revision 2 of MPR-4153 that would include expanded discussions to address the staff's questions. In its response to RAI B.2.1.31A-5(a3) the applicant revised its approach for monitoring through-thickness expansion to install extensometers in all Tier 3 locations and added such to Commitment 83. In its response to RAI B.2.1.31A-5(a4) the applicant stated that it will monitor volumetric effects of ASR and provided detailed discussion of the technical methodology underlying its proposed approach. In this submittal, the applicant also provided an updated LRA Section B.2.1.31A.

- Staff held a public meeting on April 28, 2016, to discuss technical issues related to the applicant's December 3, 2015, submittal. The meeting summary was issued on June 8, 2016 (ML16146A172).

- By letter dated August 9, 2016, the applicant submitted a supplement to its LRA (ML16224B079) providing additional information as discussed with the staff during the April 28, 2016, public meeting. The applicant also submitted an updated ASRMP AMP that superseded the previous submittal, and an additional plant-specific BDMP. The staff's review of the BDMP is in Section 3.0.3.3.7. In addition, in August 2016 the applicant also submitted license amendment request LAR 16-03 to the NRC requesting an amendment to its operating license to account for ASR effects. The applicant indicated that the AMPs are consistent with the methodologies presented in the LAR and that any changes resulting from NRC's review of the LAR would be reflected in the AMPs. The staff performed an onsite audit October 25-27, 2016, to review the applicant's AMP submittal (ML16333A247).

- RAI B.2.1.31A-A1, B.2.1.31A-A2, B.2.1.31A-A3, and B.2.1.31A-A4 (based on the audit of the applicant's August 9, 2016, submittal) issued by letter dated November 30, 2016 (ML16326A037): RAI B.2.1.31A-A1 requested that the applicant discuss the way it was crediting volumetric expansion measurements and state how the program will use CCI to manage ASR-induced rebar stresses and strains such that they remain within design code limits. RAI B.2.1.31A-A2 requested that the applicant clarify the inspection interval planned for monitoring through-wall expansion. RAI B.2.1.31A-A3 requested that the applicant clarify whether the structural evaluations referred to in the ASR Monitoring Program are the same as those performed in the BDMP. RAI B.2.1.31A-A4 requested that the applicant state how it will validate and verify the behavior of ASR-affected structures as modeled in the large-scale testing program.

- Responses to RAIs B.2.1.31A-A1, -A2, -A3, and –A4 and clarifications to its ASR Monitoring program and related commitments provided by letter dated December 23, 2016 (ML16362A283): In its response to RAI B.2.1.31A-A1 the applicant explained and provided the technical basis for how volumetric expansion will be monitored and assessed. It also stated that it will evaluate rebar stresses and strains relative to the applicable design code. In its response to RAI B.2.1.31A-A2 the applicant stated that snap-ring borehole extensometer measurements will be conducted on a six-month frequency. In its response to RAI B.2.1.31A-A3 the applicant confirmed that the structural evaluations referenced in the ASR Monitoring program are those being carried out in the BDMP. In response to B.2.1.31A-A4 the applicant detailed its plans for future corroboration the correlation between modulus of elasticity and through-wall expansion to-date. The applicant added two Commitments for the corroboration activities: Commitment 45 was added to corroborate the methodology described in MPR-4153 at least two (subsequently changed to five) years prior to PEO and 10 years thereafter; and Commitment 66 stated that the applicant will conduct a periodic assessment of ASR expansion behavior at least 5 years prior to PEO and every 10 years thereafter. In this submittal, the applicant also included an updated LRA Section B.2.1.31A.

- RAI B.2.1.31A-A1-1, B.2.1.31A-A4-2 issued by letter dated March 29, 2017 (ML17088A614): RAI B.2.1.31A-A1-1 requested justification for not having acceptance criteria for volumetric expansion. RAI B.2.1.31A-A4-2 requested information regarding acceptance criteria associated with the planned corroboration studies, and justification for why taking three cores at one point in time will sufficiently corroborate conclusions from the LSTP being applicable to Seabrook structures.

- Responses to RAIs B.2.1.31A-A1-1 and B.2.1.31A-A4-2 dated October 3, 2017 (ML17277B519): In response to RAI B.2.1.31A-A1-1 the applicant stated that it will incorporate volumetric expansion as a new monitoring parameter in the "parameters monitored or inspected,", "detection of aging effects," and "monitoring and trending" program elements and provided acceptance criteria in the "acceptance criteria" program element. The frequency of examination will be consistent with the monitoring intervals for the in-plane and through-wall expansion measurements. In response to RAI B.2.1.31A-A4-2 the applicant modified its proposal to corroborate in-situ expansion behavior with the LSTP (see Operating Experience program element in Section 3.0.3.3.6 below).

- By letter dated November 3, 2017 (ML17307A027), the applicant submitted a revised ASR Monitoring program.

- By letter dated December 11, 2017 (ML18141A785), the applicant submitted a Methodology Document that the applicant stated serves as a basis for the ASR Monitoring program. The staff performed an on-site audit from March 19-22, 2018, to review the applicant's submittal (ML18135A046).

The staff reviewed program elements one through six, and ten, of the applicant's ASR Monitoring Program against the acceptance criteria for the corresponding elements as stated in SRP-LR Section A.1.2.3. The staff's review focused on how the applicant's program manages cracking due to expansion from reaction with aggregates through the effective incorporation of these program elements. The staff verified that program elements seven through nine, "corrective actions," "confirmation process," and "administrative controls," were consistent with the guidance in SRP-LR Appendix A.1, during the audit conducted on November 18–20, 2013. The staff also noted during its March 19-22, 2018, audit that these program elements are being effectively implemented. The staff's evaluation of these program elements is documented in SER Section 3.0.4. As stated earlier in this Section, the applicant applied to amend its licensing basis to account for the effects of ASR. In its review of license amendment request (LAR) 16-03, "Revise Current Licensing Basis to Adopt a Methodology for the Analysis of Seismic Category I Structures with Concrete Affected by Alkali-Silica Reaction," the staff assessed the technical adequacy of the applicant's LSTP, which is credited as a basis for the ASR Monitoring Program. The staff's review is documented in its Safety Evaluation Related to LAR 16-03, (ML18204A282 proprietary;

ML18204A291 non-proprietary.) Therefore, the staff's evaluation of the adequacy of the testing methodology and the conclusions from the LSTP credited in the ASR Monitoring Program will not be discussed in this SER.

Scope of Program. LRA Section B.2.1.31A states that the scope of the program includes concrete structures within the scope of the Structures Monitoring Program and the ASME Section XI, Subsection IWL Program. The program proposes to manage the aging effect of cracking due to expansion from reaction with aggregates during the period of extended operation. The LRA lists the specific Seismic Category 1 structures, Miscellaneous Non-seismic Category 1 Yard structures, and Non-Category 1 structures included in the scope of license renewal.

The staff reviewed the applicant's "scope of program" program element against the criteria in SRP-LR Section A.1.2.3.1, which states that the scope of the program should include the specific structures and components, the aging of which the program manages. During an onsite audit, the staff verified that all concrete structures within the scope of license renewal are included in the ASR Monitoring Program.

The staff finds the applicant's "scope of program" program element to be adequate because the LRA clearly identifies all concrete structures within the scope of the program and the staff confirmed that all concrete structures within the scope of license renewal are included in the AMP.

Based on its review of the application as documented in letter dated May 18, 2018, the staff confirmed that the "scope of program" program element satisfies the criteria defined in SRP-LR Section A.1.2.3.1; therefore, the staff finds it acceptable.

Preventive Actions. LRA Section B.2.1.31A states that the ASR Monitoring Program is a condition monitoring program and does not rely on preventive actions to manage cracking due to expansion from reaction with aggregates. The staff reviewed the applicant's "preventive actions" program element against the criteria in SRP-LR Section A.1.2.3.2, which state that some condition monitoring programs do not rely on preventive actions. However, SRP-LR Section A.1.2.3.2 also states that in cases for which the condition monitoring programs may rely on preventive actions, the preventive activities should be specified.

The staff finds the applicant's "preventive actions" program element to be adequate because the ASR Monitoring Program is a condition monitoring program that does not rely on preventive actions or mitigation measures and, therefore, any mitigation measures taken need not be specified within this program element.

Based on its review of the application as documented in letter dated May 18, 2018, the staff confirmed that the "preventive actions" program element satisfies the criteria defined in SRP-LR Section A.1.2.3.2; therefore, the staff finds it acceptable.

Parameters Monitored or Inspected. LRA Section B.2.1.31A states that an initial screening process will look for visual characteristics at the surface of concrete, which typically include "map" or "pattern" cracking, surface discoloration of the cement paste surrounding the cracks, and the presence of moisture and efflorescence. The LRA states that inaccessible areas of concrete will be inspected during opportunistic or focused inspections for buried concrete every five years. The LRA also states that petrographic examination may be performed on concrete specimens to aid confirmation of the proposed diagnosis from visual inspections.

The applicant stated that for initial assessment of ASR-affected structures, it will assess extent of ASR damage by in-plane expansion measurements using the Cracking Index (summation of measurement of crack widths along a vertical or horizontal side of a section of concrete surface) on 20 inch by 30 inch grids and establish the Combined Cracking Index (CCI) for that area. The CCI is calculated by summing the widths of all cracks crossing the grid lines and dividing the sum by the total grid line length. The LRA also states that this process is described in the "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction (ASR) in Transportation Structures," by the Federal Highway Administration. The LRA further states that the criteria used in assessment of expansion are based on recommendations provided in MPR-3727, Revision 0, "Seabrook Station: Impact of Alkali-Silica Reaction on Concrete Structures and Attachments" and are supported by its LSTP.

The LRA states that for monitoring ASR progression, it will obtain measurements in both the in-plane and through-thickness directions. For the in-plane expansion, the applicant will monitor the CCI and/or embedded pin measurements. The staff noted during its on-site audit that the decision whether to monitor CCI or embedded pin measurements is based on which value is most dependably measurable in each area. The applicant stated that below 1 mm/m, direction of expansion is not significantly affected by the concrete reinforcement and thus for low expansion levels monitoring only the in-plane expansion is adequate. The applicant stated that the LSTP showed that for structures with two-dimensional reinforcement mats in the in-plane directions (the configuration for many Seabrook structures), in-plane expansion plateaued at low expansion levels, while expansion in the through-thickness direction continued to increase. Therefore, for ASR expansion greater than a CCI of 1 mm/m ("Tier 3" locations), the applicant intends to monitor the effects of ASR expansion by also measuring through-wall expansion using extensometers, and combined volumetric expansion.

In order to determine the total ASR-induced through-thickness expansion at each extensometer location, the applicant proposes to first determine the expansion at the time the extensometer is installed. The proposed method to determine expansion to-date is based on a correlation established in the LSTP between reduction in modulus of elasticity and through-wall expansion. The applicant will take cores at each extensometer location, test for the modulus of elasticity, and relate the reduction in modulus to establish expansion at the time of extensometer placement; the correlated value will then be added to the measured expansion. The staff notes that this methodology is described in Report MPR-4153, "Seabrook Station – Approach for Determining Through-Thickness Expansion from Alkali-Silica Reaction," Revision 3 (September 2017), which was submitted to the NRC in support of LAR 16-03.

The LRA states that based on the LSTP results, structural evaluations regarding ASR micro cracking should consider that there has been no adverse impact on the flexure/reinforcement anchorage and shear limit states provided that through-thickness and volumetric expansion are at or below bounding conditions of the LSTP, and expansion behavior is comparable to the test specimens, and there is no adverse impact on anchor/embedment capacity provided that in-plane expansions remain below the tested limits.

The applicant states that the inspection of inaccessible areas of concrete will be performed during opportunistic or focused inspections for buried concrete performed under the Maintenance Rule every five years. The staff confirmed during its ASR-focused Inspection Procedure (IP) 71002 inspection (conducted May 1-3, 2018) that the applicant will include a periodic maintenance task to trigger focused inspection of inaccessible concrete if no opportunistic inspections have been conducted during the monitoring interval.

The staff reviewed the applicant's "parameters monitored or inspected" program element against the criteria in SRP-LR Section A.1.2.3.3, which states that the program element should identify the aging effects that the program manages and provide a link between the parameters being monitored and how monitoring those parameters will ensure adequate aging management. SRP-LR Section A.1.2.3.3 also states that, for condition monitoring programs, the parameter monitored or inspected should be capable of detecting the presence and extent of aging effects.

The staff notes that as evidenced through correspondence with the applicant noted above, the program has been revised several times and the applicant's bases supporting the "parameters monitored or inspected" program element have been docketed. The staff also notes that the technical adequacy of the LSTP has been reviewed by the staff and the conclusions of the LSTP have been found acceptable. The staff's review of the technical aspects of the LSTP is documented in the Safety Evaluation Related to LAR 16-03. The staff finds the applicant's "parameters monitored or inspected" program element to be adequate because:

1. The program uses visual inspections, in accordance with GALL Report recommendations, to identify ASR suspect areas for additional monitoring (e.g., CCI or embedded pins).

2. CCI was found to correlate with concrete strain values which were directly measured in the LSTP and wherever possible, embedded pins will be used to directly measure concrete and rebar strain (rebar strain is also discussed in Section 3.0.3.3.7 of this SER).

3. ASR expansion is being monitored using in-plane, through-wall, and volumetric measurement, which is appropriate since ASR expansion occurs in all directions. The LSTP considered volumetric expansion and observed no adverse structural implications for the limit states tested.

4. MPR-4288, "Seabrook Station: Impact of Alkali-Silica Reaction on Structural Design Evaluations," (submitted as part of LAR 16-03) discusses the applicant's rationale for choosing the limit states and design considerations to be examined for the

LSTP; and the staff determined that the chosen limit states are bounding of potential impact to intended function of ASR-affected structures. The parameters monitored in the ASR Monitoring Program are the same as those monitored in the LSTP.

5. The LSTP confirmed that at low levels of ASR progression, in-plane and through-wall cracking are generally similar. The staff agrees that monitoring less severe ASR locations initially via CCI and embedded pins, and installing an extensometer once ASR has progressed greater than 1 mm/m will allow the program to identify severity of ASR progression. This conclusion will be confirmed prior to the PEO and periodically thereafter (Commitment #66).

6. A reduction in modulus of elasticity was correlated to through-wall expansion measurements and confirmed for structures studied in the LSTP. This allows for total expansion to be known for Seabrook structures such that it can be compared to expansion levels tested. The applicant committed (Commitment #66) to corroborate that correlation prior to the PEO and periodically thereafter.

7. In its June 30, 2015, response to RAI B.2.1.31a-5(a), the applicant stated that core bores removed to install the out-of-plane extensometers will be inspected to rule out laminar cracking in Tier 3 locations, and that 34 cores removed did not reveal any evidence of laminar cracking. The applicant committed (Commitment #66) to periodically inspect cores for mid-plane cracking when removed for each corroboration study.

8. The AMP includes opportunistic or focused inspections of inaccessible areas. In addition, as stated in the applicant's June 30, 2015, response to RAI B.2.1.31a-6(a), several inspections of inaccessible areas have been performed; and results to date have confirmed that the levels of ASR observed in inaccessible areas have been consistent with that observed in accessible areas.

Based on its review of the application, as revised by letter dated May 18, 2018, and review of the applicant's response to RAIs, the staff confirmed that the "parameters monitored or inspected" program element satisfies the criteria defined in SRP-LR Section A.1.2.3.3; therefore, the staff finds it acceptable.

Detection of Aging Effects. LRA Section B.2.1.31A states that monitoring walkdowns are performed on a periodic basis. The Structures Monitoring Program performs visual inspections to identify areas that indicate ASR and require expansion measurements in accordance with the ASR AMP. For in-plane expansion, the CCI of ASR-affected areas is measured. The frequency of Tier 2 (CCI < 1.0 mm/m) location inspections is every 2.5 years. The frequency of Tier 3 (CCI ≥ 1.0 mm/m) location monitoring is on a six-month basis. The LRA states that for areas where the structural evaluations performed under the BDMP indicate more frequent CCI or pin-to-pin monitoring is required, the program defaults to the more frequent interval. Tier 3 areas will also be monitored in the through-thickness direction with Snap-Ring Borehole Extensometers (SRBEs). The LRA states that the applicant evaluated the performance of several instrument types over the course of a year and the SRBE was chosen because of its reliable performance. The LRA states that cores removed for installation of SRBEs will be visually examined to confirm the absence of a mid-plane crack. For volumetric expansion, the program will monitor volumetric expansion using the CCI and extensometer measurements at Tier 3 locations on a six-month interval.

The staff reviewed the applicant's "detection of aging effects" program element against the criteria in SRP-LR Section A.1.2.3.4, which states that the program element should address how the program would detect the occurrence of age-related degradation, prior to a loss of intended function. This element should also discuss "when," "where," and "how" data will be collected. For condition monitoring programs, the SRP-LR states that the inspection method or technique and frequency of inspection should be justified.

The staff notes that the technical adequacy of the LSTP has been reviewed by NRC staff and the conclusions of the LSTP have been found to serve as an adequate basis for managing the aging effect of "cracking due to expansion caused by reaction from aggregates." The staff's review of the technical aspects of the LSTP is documented in the staff's SE related to LAR 16-03. The staff finds the applicant's "detection of aging effects" program element to be adequate because:

1. The applicant’s method for identifying the presence of ASR is the performance of visual inspections for characteristics of ASR at the concrete surface. The staff agrees that visual examinations are sufficient to detect ASR prior to it having any impact on structural function. In addition, in its November 2, 2012, response to RAI B.2.1.31-5, the applicant stated that visual inspections will be used to monitor the progression of ASR, and will not be used to rule out its presence. The staff finds that using visual indications of ASR to identify its presence will adequately detect ASR prior to a loss of intended function. The program also conservatively assumes ASR to be a credible aging effect for all concrete structures on site.

2. The AMP includes opportunistic or focused inspections of inaccessible areas. In addition, as stated in the applicant’s June 30, 2015, response to RAI B.2.1.31a-6(a), the applicant has performed several inspections of inaccessible areas and results to date have confirmed that the levels of ASR observed in inaccessible areas have been consistent with that observed in accessible areas. The applicant also stated that if a Tier 2 or 3 ASR location is identified during an opportunistic or focused inspection of an inaccessible area, the re-inspection would occur at the prescribed frequency and methods for that Tier. During its May 1-3, 2018, 71002 inspection, the staff confirmed that periodic maintenance protocols are being put into place to ensure that a focused inspection is performed during the five year inspection interval if no opportunistic inspection can be credited.

3. ASR expansion progresses slowly; the frequent 6-month expansion monitoring period for the most severe ASR degradation locations is conservative, which provides reasonable assurance that a loss of intended function could be detected prior to the next scheduled inspection.

4. ASR will be monitored for in-plane and out-of-plane expansion and the volumetric data will be considered. The staff finds that using all three indications is adequate since ASR expansion occurs in all directions. Using volumetric data to detect expansion as a whole and ensuring that the expansion levels are bounded by the volumetric expansion of the LSTP also serves to address small variations between the test specimens compared to Seabrook structures in through-wall vs. in-plane expansion.

5. As discussed in the “operating experience” program element, the applicant committed (Commitment 66) to confirm the observation from the LSTP that expansion is initially similar in all directions but then as ASR progresses, preferentially expands in the through-thickness direction. The applicant will confirm this observation at least five years prior to PEO and every 10 years thereafter.

Based on its review of the application, as revised by letter dated May 18, 2018, and review of the applicant’s response to RAIs, the staff confirmed that the “detection of aging effects” program element satisfies the criteria defined in SRP-LR Section A.1.2.3.4; therefore, the staff finds it acceptable.

Monitoring and Trending. LRA Section B.2.1.31A states that the program will measure the progression of ASR in the in-plane and through-thickness directions using in-plane measurements (CCI or embedded pins), out-of-plane measurements (snap-ring borehole extensometers), and volumetric expansion assessments to apply the test results from the LSTP and trend data. The program will consider the rate at which a location is approaching the CCI and expansion limits and will use that information to take actions to ensure continued structural adequacy.

The staff reviewed the applicant’s “monitoring and trending” program element against the criteria in SRP-LR Section A.1.2.3.5, which state that this program element should describe the monitoring and trending activities and “how” the data collected are evaluated.

The staff finds the applicant’s “monitoring and trending” program element to be adequate because:

1. The program will inspect all “Tier 3” (i.e., most severe) ASR locations and not a sample, therefore considerations for sample selection representativeness are not needed, as discussed in RAI B.2.1.31A-5(a3) and its response, dated December 3, 2015.

2. The applicant stated in its May 15, 2014, response to RAI B.2.1.31A-2 that the Tier 3 inspection frequency was established based on guidance provided in the FHWA’s “Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction

(ASR) in Transportation Structures," the Tier 2 frequency was determined to be an interim interval between Tier 1 and Tier 3, and current inspection results indicate the Tier 2 interval has been adequate to monitor ASR progression. During its March 19-22, 2018, onsite audit the staff reviewed several years of inspection results to date and confirmed that this frequency is adequate to monitor ASR progression such that degradation can be detected prior to a loss of intended function (noting that ASR expansion in Tier 2 areas is not advanced). Since the ASR progression has been slow, the staff has reasonable assurance that inspection intervals are adequate to identify whether ASR expansion will reach tested levels prior to the next inspection. In addition, the applicant stated that it will review the rate at which a location is approaching the established limit and take action if the limit is anticipated to be exceeded prior to the next planned inspection.

3. As noted in the February 25, 2015, responses to RAIs B.2.1.31A-2(a) and B.2.1.31-7, although the inspection intervals of Tier 2 and Tier 3 ASR-affected areas currently specified in the ASR Monitoring Program may change based on trending of previous inspection results, the inspection interval will not exceed the maximum inspection interval of five years specified in the Structural Monitoring Program for components in a harsh environment. This is adequate because even if inspection frequencies are changed due to lack of or very slow expansion, a (maximum) five-year interval will be consistent with inspection guidelines contained in Chapter 6 of ACI 349.3R-96 and GALL Report recommendations.

Based on its review of the application, as revised by letter dated May 18, 2018, and review of the applicant's response to RAIs, the staff confirmed that the "monitoring and trending" program element satisfies the criteria defined in SRP-LR Section A.1.2.3.5; therefore, the staff finds it acceptable.

<u>Acceptance Criteria</u>. LRA Section B.2.1.31A states that any area with visual presence of ASR (as defined in Federal Highway Administration's FHWA-HIF-12-022) and a cracking index (CI) of less than 0.5 mm/m in the vertical and horizontal direction is considered Tier 2 and is monitored qualitatively. Areas with CI greater than or equal to 0.5 mm/m in the vertical and horizontal directions or a combined cracking index (CCI) (average of the CI values in either direction) of 0.5 mm/m or above are also classified as Tier 2 but are monitored quantitatively (via CCI measurements) and trended. The LRA states that using a CCI threshold of 0.5 mm/m for quantitative monitoring is used because individual crack widths smaller than .05 mm/m cannot be accurately measured and reliably repeated with standard visual inspection equipment.

For CCI greater than or equal to 1.0 mm/m, the LRA states that a structural evaluation and through-thickness expansion monitoring is required, and that the structural evaluation performed for the BDMP AMP (Section 3.0.3.3.7 of this SER) fulfills this requirement. For ASR-affected structures within the scope of the ASR AMP but not within the scope of the BDMP AMP, if a structural evaluation does not exist one will be performed. If a structural evaluation has been performed the program will verify that the in-plane expansion included in the structural evaluation bounds the as-found condition, or will update the existing evaluation to bound the as-found condition and provide margin for future expansion. For Tier 3 areas, the LRA states that the acceptance criteria for structural evaluation were developed from the applicant's LSTP. Specific criteria for in-plane and out-of-plane expansion are in FP#101020 Section 2.1, and the criteria for volumetric expansion are in FP#101050 Appendix B.

The staff reviewed the applicant's "acceptance criteria" program element against the criteria in SRP-LR Section A.1.2.3.6, which states that the acceptance criteria of the program and its basis should be described. The acceptance criteria should ensure that the intended functions are maintained consistent with all CLB design conditions during the period of extended operation.

The staff notes that the technical adequacy of the LSTP has been reviewed by NRC staff and the conclusions of the LSTP have been found to establish adequate basis for acceptance criteria for concrete degradation from cracking due to expansion from reaction with aggregates. The staff's review of the technical aspects of the LSTP is documented in the staff's Safety Evaluation related to LAR 16-03. The staff finds the applicant's "acceptance criteria" program element to be adequate because:

1. For ASR expansion only, acceptance criteria used was determined from testing of large-scale specimens comparable to Seabrook structures that were tested to the Seabrook design basis limits for the most critical limit states (the staff notes that all limit states were assessed and that this is discussed in revised report MPR 3727, which was submitted in the applicant's May 18, 2018 letter).

2. The acceptance criterion of 1 mm/m as the point at which a structural evaluation is needed allows for the program to verify that in-plane expansion is adequately bounded in the overall evaluation. This is acceptable because the ASR AMP will provide input into the structural evaluations conducted under the BDMP AMP to ensure that in-plane expansion is adequately accounted for with regards to the structure's ability to perform its intended function(s).

3. The ultimate limits for expansion are based on the LSTP, which the staff has determined (in its review of LAR 16-03) that, up to the values tested in the program, there is no impact on structural intended function.

Based on its review of the application, as revised by letter dated May 18, 2018, the staff confirmed that the "acceptance review" program element satisfies the criteria defined in SRP-LR Section A.1.2.3.6 and, therefore, the staff finds it acceptable.

Operating Experience. LRA Section B.2.1.31A summarizes operating experience related to the ASR Monitoring Program. The LRA states that, historically, the below-grade walls of Seabrook concrete structures have experienced groundwater infiltration. The LRA indicates that an evaluation was conducted in the 1990s to assess the effect of groundwater infiltration, which "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." Seasonal groundwater samples taken in 2009, to support the development of the LRA, indicated that the groundwater had become aggressive. The LRA further states that a comprehensive review of possible effects due to the aggressive nature of the groundwater was initiated, which showed the presence of ASR and reductions in compressive strength and elastic modulus of the affected concrete. The LRA states that an engineering evaluation concluded that the impacted structures were capable of performing their safety function but with reduced margin.

The LRA states that NextEra Energy will update the ASR Monitoring Program AMP for any new plant-specific or industry Operating Experience (OE), including ongoing industry studies and research if applicable. The LRA also states that it submitted a license amendment request in accordance with 10 CFR 50.90 to incorporate a revised methodology related to ASR material properties and building deformation analysis for review and approval (LAR 16-03). The staff's review of the LSTP and its conclusions, which are credited as the basis of the ASR Monitoring Program, are documented in the staff's Safety Evaluation related to LAR 16-03.

The LRA discusses several opportunistic inspections of buried concrete and indicated that there have not been any observations to date where ASR degradation was not bounded by the conditions of accessible concrete. The applicant stated and the staff confirmed during its onsite audit that areas that were identified to have ASR meeting the limits of Tier 2 or Tier 3 were included in the periodic inspection for the corresponding Tier.

The LRA discusses several actions the applicant plans to take to confirm that the expansion behavior observed in Seabrook structures is consistent with the observations from the LSTP. The applicant stated that at least 5 years before the PEO and every 10 years thereafter the applicant will periodically confirm expansion behavior by:

1. Reviewing records for cores removed to date or since the last assessment to confirm there is no mid-plane cracking.

2. Comparing in-plane expansion (x- and y-directions) with through-wall (z-direction) observed on site against a plot of CCI to through-wall expansion from the LSTP to confirm that expansion initially is similar in all directions, but becomes preferential in the z-direction.

3. Comparing measured expansions to limits from the LSTP to check margin for future expansion.

In addition, the applicant stated that at least 5 years before the PEO (initial study) and 10 years thereafter (followup study), a study will be completed to corroborate modulus-expansion correlation with plant data. In the study, for 20% of extensometer locations the applicant will compare through-wall expansion determined from the LSTP modulus-expansion correlation with through-wall extensometer measurements and the original elastic modulus reduction result used to initially determine through-wall expansion to date at the time of extensometer installation. The applicant stated that a detailed explanation of the approach for validation of expansion behavior is provided in Report MPR-4273 Revision 1, which was submitted to the NRC in letter dated May 18, 2018.

The staff reviewed this information against the acceptance criteria in SRP-LR Section A.1.2.3.10, which states that consideration of future plant-specific and industry operating experience relating to AMPs should be discussed. The operating experience of AMPs that are existing programs, including past corrective actions resulting in program enhancements or additional programs, should also be considered. For new AMPs that have yet to be implemented, the SRP states that an applicant should commit to a review of future plant-specific and industry operating experience for new programs to confirm their effectiveness.

The staff reviewed operating experience information in the application and during the March 19-22, 2018, audit to determine if the applicable aging effects and industry and plant-specific operating experience were reviewed by the applicant. The staff finds the Operating Experience program element acceptable because:

1. From its review of the LRA and onsite review of AMP basis documents, the corrective action program and implementing procedures, the staff noted that the applicant's program appropriately identifies plant-specific operating experience and has used that operating experience to make necessary adjustments to the program to ensure it continues to manage ASR effects on structural functionality.

2. The program will continue to monitor industry and plant-specific operating experience, including relevant national and international research, and will modify the program as necessary.

3. The applicant committed (Commitment #66) to verify expansion behavior of Seabrook structures in comparison to expansion of the LSTP specimens, specifically the observation that in-plane expansion plateaus at lower levels of ASR expansion and that through-wall expansion dominates. This corroboration is significant because through-wall expansion data obtained in the LSTP is credited as the basis for continued functionality of Seabrook structures.

4. In its response to RAI B.2.1.31A-A4-2 (dated October 3, 2017) the applicant revised Commitment #45 regarding corroborating of Seabrook structure expansion behavior (specifically the modulus-expansion correlation) to the LSTP, from examining 3 areas at one point in time to examining 20% of through-wall locations once 5 years prior to the PEO and 10 years thereafter. The staff finds that the sample number and frequency provide for a meaningful validation prior to the PEO and appropriate reevaluation during the PEO.

Based on its audit and review of the application, and review of applicable RAI responses, the staff finds that operating experience related to the applicant's program demonstrates that it can adequately manage the detrimental effects of aging on SSCs within the scope of the program and that implementation of the program has resulted in the applicant taking appropriate corrective actions. The staff confirmed that the "operating experience" program element satisfies the criterion in SRP-LR Section A.1.2.3.10.

UFSAR Supplement. LRA Section A.2.1.31A provides the UFSAR supplement for the ASR Monitoring Program. The staff reviewed this UFSAR supplement description of the program against the recommended description for this type of program as described in SRP-LR Table 3.0-1. This guidance states that the program description should contain information associated with the bases for determining that aging effects will be managed during the period of extended operation.

The staff also noted that the applicant committed (Commitment No. 71) to implement the ASR Monitoring Program prior to the period of extended operation for managing the effects of aging for applicable components. The staff also noted that the applicant committed (Commitment No. 83) (1) to install extensometers in all Tier 3 areas of two dimensionally reinforced structures to monitor expansion due to alkali-silica reaction in the out-of-plane direction; and (2) to monitor expansion in the out-of-plane direction upon installation of extensometers and continue on a six month frequency through the period of extended operation. The staff notes that the applicant has completed extensometer installation in applicable locations, and is monitoring through-wall expansion on a six-month frequency; thus this Commitment has been completed. The applicant also committed (Commitment Nos. 45 and 66) to periodic confirmation of expansion behavior. Specifically, at least 5 years prior to the PEO and 10 years thereafter:

1. To verify that there is no mid-plane cracking, the applicant will review records for cores removed to date or since the last assessment.

2. To verify that expansion is initially similar in all directions but becomes preferential in the z-direction, the applicant will compare measured in-plane expansion to through-thickness expansion using a plot of through-thickness expansion versus combined cracking index (CCI) as compared to the observations in the LSTP.
3. To verify that expansions within the range observed in the LSTP, the applicant will compare measured in-plane (x- and y-), out of plane (z-) and volumetric expansions observed in Seabrook structures to the limits from the LSTP, to check margin for future expansion as it relates to structural capacity.
4. To corroborate the modulus of elasticity to expansion correlation used to determine expansion at the time of extensometer installation, the applicant will remove additional cores from 20% of the Tier 3 areas of Seabrook structures and compare to correlation curve developed from LSTP observations.

The staff determined that the information in the UFSAR supplement, as amended by the commitments provided, is an adequate summary description of the program, as required by 10 CFR 54.21(d) and is, therefore, acceptable.

Conclusion. On the basis of its technical review of the applicant's ASRMP, the staff concludes that the applicant demonstrated that, through the use of this AMP, the effects of aging of concrete structures affected by ASR will be adequately managed so that the intended function(s) of the structures under consideration will be maintained consistent with the CLB for the period of extended operation, as required by 10 CFR 54.21(a)(3). The staff also reviewed the UFSAR supplement for this AMP and concludes that it provides an adequate summary description of the program, as required by 10 CFR 54.21(d).

3.0.3.3.7 Building Deformation Monitoring Program

As documented in Seabrook Station, Unit No. 1 – Integrated Inspection Report 05000443/2015002 (ADAMS Accession No. ML15217A256), in the 2014/2015 timeframe, Seabrook Station discovered operating experience in structures affected by ASR, as described below, potentially attributable to ASR causing global bulk expansion of concrete. The report indicates that the applicant's evaluation of the degraded conditions confirmed that the identified deformation is due to bulk expansion from long term cumulative effects of ASR and strain associated with creep. In several NRC Inspection Reports 05000443/2014003 (ADAMS Accession No. ML14212A458), 05000443/2014005 (ADAMS Accession No. ML15037A172), 05000443/2015002, and 05000443/2014009 (ADAMS Accession No. ML14349A751), the NRC staff noted the following indications:

- Relative deformation (differential movement) of the Containment Enclosure Building (CEB) indicated by changes in the 3-inch seismic gaps or annulus gap between adjacent structures, damaged fire seals, misalignment of conduits/piping at penetrations or between adjacent structures, deformed flexible conduit couplings, bent small pipes/conduits and supports, etc.
- Discrete wide horizontal cracking, spalling, doorway misalignments, etc. in the Residual Heat Removal (RHR) and Containment Spray (CS) Vault.
- Cracking, displacements or other indications of structural conditions adverse to quality associated with the Fuel Storage Building (FSB).

In its June 30, 2015, submittal, the applicant stated that the ASRMP would include additional monitoring focused on identifying signs of the relative building deformation and included a new commitment to enhance the ASRMP to monitor for building displacement using laser targets and by taking gap measurements. The staff found this proposal insufficient because it was overly vague and did not appear to fully characterize the phenomena observed by the operating experience, thus it was not clear that the aging management activities would be sufficient to manage this aging degradation.

Therefore, by letter dated October 2, 2015, the NRC issued RAI B.2.1.31A-8, requesting that the applicant address various issues regarding aging management of structures affected by global manifestations of ASR. The applicant's letter dated December 3, 2015 (ADAMS Accession No. ML15343A470), contained the applicant's response to RAI B.2.1.31A-8, a revised ASRMP AMP and a revised list of commitments, including a revised Commitment No. 91 to address building deformation. At the time NextEra submitted its response it had identified that gross relative deformation at the CEB was attributed to ASR, but had not definitively attributed ASR to observed operating experience (macro cracking) in other structures.

The staff determined that it did not have sufficient information regarding aging management for building deformation caused by ASR and also did not have a clear understanding of how results of testing at the University of Texas FSEL would correlate to Seabrook structures. The staff determined the need to request additional information, and NextEra and the staff agreed to conduct a public meeting to discuss the staff's concerns. The meeting was held on April 28, 2016 (ADAMS Accession No. ML16109A004). During the meeting, the applicant stated that it would submit a supplement to the previous ASRMP, and subsequently did so by letter dated August 9, 2016 (ADAMS Accession No. ML16224B079).

The applicant's August 9, 2016, letter included two aging management programs, the ASR Monitoring Program (which was an update to the program submitted in 2012 and amended in 2015) and the Building Deformation Monitoring Program (BDMP), an additional plant-specific program to address the effects of building deformation caused primarily by ASR. The applicant also submitted license amendment request (LAR) 16-03 dated August 1, 2016 (ADAMS Accession No. ML16216A240), and LAR Supplement dated September 30, 2016 (ADAMS Accession No. ML16279A048). This LAR amends the CLB for evaluating ASR-affected structures at Seabrook and also forms a technical basis for the ASR-related AMPs for license renewal. This SER section addresses the staff's evaluation of aging management aspects of building deformation for the period of extended operation as part of the staff's review of the license renewal application (LRA); the staff's review of the adequacy of the technical bases supporting the AMPs that are also applicable to the current licensing basis are documented in the staff's Safety Evaluation (SE) related to LAR 16-03. The staff evaluation of the plant-specific ASRMP is documented in SER Section 3.0.3.3.6.

Summary of Technical Information in the Application. LRA Section B.2.1.31B states that the BDMP is a new plant-specific program being implemented under the existing Maintenance Rule SMP. The LRA states that building deformation is an aging mechanism that may occur as a result of other aging effects of concrete. The LRA also states that building deformation is primarily a result of ASR (described in LRA section B.2.1.31A) but can also result from swelling, creep, and shrinkage. The LRA further states that building deformation can cause components within the structures to move such that their intended functions may be impacted.

The program uses visual inspections and cracking measurements from the SMP and ASRMP to identify buildings experiencing deformation. The extent of surface cracking and field observations serve as input into an analytical model to determine the extent of deformation, threshold monitoring parameters and acceptance (threshold) limits, and frequency of required inspections. The program performs structural evaluations on buildings and components affected by deformation as necessary to validate structural performance against the design basis and ensure that the structural function is maintained. The LRA states that these evaluations also consider the impact to functionality of affected systems and components against their design bases to determine whether corrective actions are needed. The program credits a Methodology Document as the procedural basis. The Methodology Document was submitted to the NRC by letter dated December 11, 2017 (ADAMS Accession No. ML17345A641), under LAR 16-03. Evaluations performed in accordance with the Methodology Document are credited for aging management. The staff's detailed review of the technical aspects of the Methodology Document is documented in the Safety Evaluation related to LAR 16-03.

The August 9, 2016, LRA Section B.2.1.31B was subsequently revised by letters dated December 23, 2016, November 3, 2017, and May 18, 2018 (ADAMS Accession Nos. ML16362A283, ML17307A027, and ML18141A785, respectively).

Staff Evaluation. In support of its review of the BDMP, the NRC staff conducted several onsite audits. During its audits, the staff reviewed the applicant's BDMP against the requirements of 10 CFR Part 54; and guidance provided in SRP-LR Appendix A.1, "Aging Management Review—Generic" and the GALL Report, to confirm that the AMP will adequately manage the effects of aging for structures affected by ASR and/or building deformation. The table below lists the audit dates, locations, and documentation:

Dates of Audit	**Location**	**Audit Report ADAMS Accession No.**
October 25-27, 2016	Seabrook Station	ML16333A247
March 19-22, 2018	Seabrook Station	ML18135A046

During its review, the staff required several Requests for Additional Information (RAIs) to address its questions related to the applicant's proposal to manage the effects of ASR on structures' intended functions. As the applicant continued to evaluate the staff's questions, there were several revisions to the BDMP AMP. Unless otherwise noted, the staff's evaluation relates to the latest version of the BDMP submitted by letter dated May 18, 2018. Previous versions of the AMP and prior RAIs are only discussed as necessary to support the staff's conclusions. A summary of the RAIs and the responses are discussed briefly below, followed by the staff's evaluation of each of the program elements in the BDMP dated May 18, 2018.

- RAI B.2.1.31B-B1 and -B2 issued by letter dated December 12, 2016: RAI B.2.1.31B-B1 requested information on why the list of structures included in the scope of the ASR Monitoring Program and the ASR-related BDMP was not consistent between the programs. RAI B.2.1.31B-B2 requested that for each structure in the scope of the program, provide a list of parameters monitored and their monitoring method(s); or provide a comprehensive discussion of the processes and procedures for determining the parameters to monitor and monitoring method(s), in a manner that would demonstrated repeatability of the process.

- RAI B.2.1.31B-B1 and –B2 responses provided by letter dated December 23, 2016: In the RAI B.2.1.31B-B1 response, the applicant added the Intake and Discharge Transition Structures into the scope of the program. The applicant explained that Non-Category 1 structures including Yard structures, with the exception of Intake and Discharge Transition structures, are not included in the scope of program due to not being expected to be susceptible to deformation based on configuration. In the RAI B.2.1.31B-B2 response, the applicant provided a general overview of the methodology used to determine parameters monitored, but did not demonstrate a repeatable and specific methodology for use to define parameters monitored for any structure.
- RAI B.2.1.31B-B2-1 (Follow-up to RAI B.2.1.31B-B2) issued by letter dated March 16, 2017: stated that the staff did not find the applicant's methodology to be repeatable, and could not necessarily be applied consistently. Staff requested that since the general methodology could not be verified to reliably determine the parameters monitored, that the applicant provide these parameters for each structure and demonstrate the capability of the parameters for detecting the presence and extent of aging effects. A public meeting was held on May 9, 2017, to discuss the staff's concerns (ADAMS Accession Nos. ML17137A029).
- By letter dated November 3, 2017, the applicant submitted a revised ASRMP. By letter dated December 11, 2017, the applicant submitted a Methodology Document that the applicant stated serves as a procedural basis for the BDMP. The staff performed an on-site audit March 19-22, 2018, to review the applicant's submittal (ADAMS Accession Nos. ML18135A046).

The staff reviewed program elements one through six, and ten, of the applicant's program against the acceptance criteria for the corresponding elements as stated in SRP-LR Section A.1.2.3. The staff's review focused on how the applicant's program manages building deformation through the effective incorporation of these program elements. The staff verified that program elements seven through nine, "corrective actions," "confirmation process," and "administrative controls," were consistent with the guidance in SRP-LR Appendix A.1 during the audit conducted on March 19-22, 2018; the staff also noted during its audit that these program elements are being effectively implemented. The staff's evaluation of program elements seven through nine is documented in SER Section 3.0.4. As stated earlier in this Section, the licensee requested to amend its licensing basis to account for ASR. In its review of license amendment request (LAR) 16-03, "Revise Current Licensing Basis to Adopt a Methodology for the Analysis of Seismic Category I Structures with Concrete Affected by Alkali-Silica Reaction," the staff assessed the technical adequacy of the applicant's large-scale testing program (LSTP), which is also credited as a technical basis for the Building Deformation Monitoring Program. The staff's review is documented in its Safety Evaluation Related to LAR 16-03, (ADAMS Accession Nos. ML18204A282 proprietary; ML18204A291 non-proprietary). Therefore, the adequacy of the testing methodology and the conclusions from the LSTP will not be discussed in this SER.

Scope of Program. LRA Section B.2.1.31B states that the scope of the program includes concrete structures within the scope of the SMP and the ASME Section XI, Subsection IWL Program. The program proposes to manage the aging effect of building deformation due to expansion from reaction with aggregates, during the period of extended operation. The LRA lists the specific Seismic Category 1 and Non Category 1 structures included in the scope of license renewal.

The staff reviewed the applicant's "scope of program" program element against the criteria in SRP-LR Section A.1.2.3.1, which state that the scope of the program should include the specific structures and components, the aging of which the program manages. During an onsite audit the staff verified that concrete structures within the scope of license renewal, and expected to be susceptible to effects of deformation due to ASR (as clarified in the RAI B.2.31B-B1 response dated December 23, 2016), are included in the BDMP.

The staff finds the applicant's "scope of program" program element to be adequate because the LRA clearly identifies all concrete structures within the scope of the program and the staff confirmed that all concrete structures within the scope of license renewal, and expected to be susceptible to deformation aging effects, are included in the AMP.

Based on its review of the application as documented in letter dated May 18, 2018, the staff confirmed that the "scope of program" program element satisfies the criteria defined in SRP-LR Section A.1.2.3.1; therefore, the staff finds it acceptable.

Preventive Actions. LRA Section B.2.1.31B states that the BDMP is a monitoring only program and does not rely on preventive actions. The staff reviewed the applicant's "preventive actions" program element against the criteria in SRP-LR Section A.1.2.3.2, which state that some condition monitoring programs do not rely on preventive actions. However, SRP-LR Section A.1.2.3.2 also states that in cases for which the condition monitoring programs may rely on preventive actions, the preventive activities should be specified.

The staff finds the applicant's "preventive actions" program element to be adequate because the BDMP is a condition monitoring program that does not rely on preventive actions or mitigation measures and, therefore, preventive or mitigation measures need not be specified within this program element.

Based on its review of the application as documented in letter dated May 18, 2018, the staff confirmed that the "preventive actions" program element satisfies the criteria defined in SRP-LR Section A.1.2.3.2; therefore, the staff finds it acceptable.

Parameters Monitored or Inspected. LRA Section B.2.1.31B states that a Methodology Document (FP# 101196) describes a process in which ASR-affected structures are initially screened for deformation and analyzed to assess the effects on structures for the self-straining loads from ASR expansion, creep, shrinkage, and swelling. The Methodology Document was submitted to the NRC by letter dated December 11, 2017 (ADAMS Accession No. ML17345A641), under LAR 16-03, and provides a detailed process for structural analysis and determination of parameters to monitor and threshold limits for each structure. The LRA provides an overview of the procedures in the Methodology Document.

The LRA states that each stage of the process (Stage One, Stage Two, and Stage Three) has increasing levels of rigor in that more advanced analysis techniques are used for increasing Stages. The LRA states (and the Methodology Document details) that the specific locations where ASR exists in each structure, and the critical areas where the margin to licensing basis structural design code and design basis acceptance criteria are most limiting, influence the locations and types of measurements that are used to monitor each structure. The LRA further states that monitoring parameters, locations, frequencies, administrative limits and threshold limits for each structure are determined based on results of the structure-specific analysis and documented in the associated structural calculation.

The parameters monitored for structures are field observations (qualitative) and measurements (quantitative) that can be used to quantify ASR loads applied to each structure, which typically include (as applicable): cracking suspect of ASR (visual), cracking not suspect of ASR (visual), other structural or material distress (visual), crack index, in-plane strain rate (using removable strain gage), through-thickness expansion (for areas installed with extensometers), through-thickness strain rate (extensometer), individual crack widths/lengths (instrument or tools to measure crack width changes, such as crack comparator, crack gages, extensometers, invar wires), seismic isolation joints (quantitative measurements), structure dimensions (quantitative measurements), and equipment/conduit offsets (quantitative measurement or visual observation).

The LRA states that there are four criteria used to determine the initial stage of analysis required to determine the monitoring parameters:

1. Structures with simple geometry that permits structural analysis using closed-form solutions and/or simple finite element models

2. Structures with localized ASR expansion, or ASR expansion affecting the structure as a whole but with only minor indications of distress

3. Structures with an apparent robust original design leading to a reasonable amount of margin to accommodate ASR demands

4. Structures that do not exhibit significant signs of distress

A Stage One analysis is a "Susceptibility Screening Evaluation," applicable to structures meeting all four criteria listed above. The LRA states that this category of evaluation applies to structures with minimal amounts of deformation that do not affect the structural capacity as determined in the original design analysis. For structures meeting two or three of the above criteria, a Stage Two

"Analytical Evaluation" is performed. The LRA states that this category applies to structures with elevated levels of deformation that are shown to be acceptable using finite element analysis to calculate ASR loads but still meeting the original design basis requirements when ASR effects are included. For structures that can only meet one or none of the above criteria, a Stage Three "Detailed Evaluation" is performed. The LRA states that this category applies to structures with significant deformation that are analyzed and shown to meet the requirements of the code of record using the methods described in the Methodology Document. The LRA states that these analyses determine the parameters monitored or inspected for each structure, and that the program monitors each parameter against determined "threshold" limits in accordance with the licensing basis. Stage One, Two, and Three structures are monitored on a 36 month, 18 month, and 6 month basis, respectively.

For components impacted by structural deformation, the LRA states that condition walk downs, looking for specific listed features (e.g., distorted or misaligned components, gaps or tears in seals, crimped tubing, bent bolts, cracked welds), are performed with a focus on safety-related components such as pumps, valves, conduits, piping, etc. The effects of deformation on plant equipment and seismic gaps will be managed through the Corrective Action Program based on input from the SMP to be dispositioned for impact on structures. Additionally, the LRA states that these inspections are in addition to installed monitoring elements such as strain measurements and measurements of the relative deformation between structures. These measurements will be performed at a frequency that ensures functionality of the affected components is not lost prior to the next inspection interval.

The staff reviewed the applicant's "parameters monitored or inspected" program element against the criteria in SRP-LR Section A.1.2.3.3, which states that the program element should identify the aging effects that the program manages and provide a link between the parameters being monitored and how monitoring those parameters will ensure adequate aging management. SRP-LR Section A.1.2.3.3 also states that, for condition monitoring programs, the parameter monitored or inspected should be capable of detecting the presence and extent of aging effects.

The staff finds the applicant's "parameters monitored or inspected" program element to be adequate because:

1. The program uses visual inspections, in addition to quantitative and instrument measurements depending on the parameter.

2. The staff reviewed the Methodology Document and determined that it is robust, with sufficient detail such that it is repeatable for any structure. The Methodology Document procedures can be used to reliably determine parameters to be monitored or inspected for an individual structure (the staff's detailed review of the Methodology Document is documented in its SE associated with LAR 16-03).

3. The program uses structure-specific analyses that are based on structure design bases and actual observed conditions and measurements to determine monitoring parameters and limits.

4. The list of parameters is reasonably complete to monitor typical features that can be observed to indicate building deformation is occurring or progressing in structures.

5. The "Staged" approach for level of detail is reasonable in that structures more susceptible to building deformation potentially affecting structure intended function(s) receive increasingly detailed evaluation.

6. Structure-specific limits are established for each parameter and are monitored to maintain within those threshold limits.

7. During its March 19-22, 2018, audit the staff reviewed a sample of Stage One, Stage Two, and Stage Three structures and verified that the analyses yielded appropriate parameters monitored, and these parameters and associated limits are implemented in the SMP procedure for each structure and specific area of monitoring.

8. The program includes inspection parameters for components that may be impacted by structural deformation.

Based on its review of the application, as revised by letter dated May 18, 2018, and review of the applicant's responses to RAIs, the staff confirmed that the "parameters monitored or inspected" program element satisfies the criteria defined in SRP-LR Section A.1.2.3.3; therefore, the staff finds it acceptable.

Detection of Aging Effects. LRA Section B.2.1.31B states that baseline walk downs are performed to identify the potential effects caused by building deformation. The results of the baseline walk downs are used to determine the key assumptions in the structural analysis. The recommended inspection frequencies for subsequent monitoring are defined in the Methodology Document and in program element "parameters monitored" in the LRA. The frequencies listed in that section are 36 months for Stage One, 18 months for Stage Two, and six months for Stage Three. The LRA notes that that those inspection frequencies will be applied in locations where symptoms of deformation are identified; otherwise, the inspection frequency will follow the requirements of the SMP. The staff notes that LRA Section B.2.1.31 states that for structures in harsh environments (defined in Section B.2.1.31), the inspection is conducted on a five year basis. The LRA states that the inspections are completed by qualified individuals at a frequency determined by the characteristics of the environment in which the structure is found. The LRA further states that the program will consider the rate of expansion and building deformation and will take appropriate action if the structural integrity of the structure and associated components are projected to be lost prior to the next inspection. The LRA also notes that walk downs and visual inspections will be conducted of components that may be impacted by building deformation.

The staff reviewed the applicant's "detection of aging effects" program element against the criteria in SRP-LR Section A.1.2.3.4, which state that the program element should address how the program would detect the occurrence of age-related degradation, prior to a loss of intended function. This element should also discuss "when," "where," and "how" data will be collected. For condition monitoring programs, the SRP-LR states that the inspection method or technique and frequency of inspection should be justified.

The staff finds the applicant's "detection of aging effects" program element to be adequate because:

1. The methods used to monitor each parameter, as described in the "parameters monitored or inspected" program element (i.e., qualitative visual examinations, quantitative crack index measurements, strain gage measurements, through-thickness extensometer measurements, quantitative crack width measurements, quantitative seismic gap measurements, quantitative measurement of structural dimensions) are adequate to detect building deformations and movements.

2. The frequencies proposed in the program are appropriate. As the staff observed in its March 19-22, 2018, audit, building deformations observed on site have progressed slowly. For Stage One structures with minimal deformation that do not affect the structural capacity as defined in the original design analysis, 36 months is adequate and the threshold for the most frequent 6-month expansion monitoring period is conservative. In addition, the program will consider the rate of expansion to the next inspection to ensure structures and components will not lose functionality prior to the next scheduled inspection. The staff observed during its March 19-22, 2018, audit that the program is currently in place and the applicant is taking measurements at the stated intervals. This provides reasonable assurance that the data will be available to determine whether a loss of intended function would occur prior to the next scheduled inspection.

3. Inspections are completed by qualified individuals, in accordance with GALL Report recommendations.

4. Monitoring areas are based on critical locations, as determined by the individual structure-specific evaluation, and as discussed in the Methodology Document

Based on its review of the application, as revised by letter dated May 18, 2018, and review of the applicant's responses to RAIs, the staff confirmed that the "detection of aging effects" program element satisfies the criteria defined in SRP-LR Section A.1.2.3.4; therefore, the staff finds it acceptable.

Monitoring and Trending. LRA Section B.2.1.31B states that once inspection frequencies are determined, visual inspections will be used to monitor and trend future building deformation. Any new indications of building deformation will be placed in the Corrective Action Program and evaluations will be performed to determine if inspection frequencies should be changed to ensure future effects of degradation are identified prior to loss of intended function.

The staff reviewed the applicant's "monitoring and trending" program element against the criteria in SRP-LR Section A.1.2.3.5, which state that this program element should describe the monitoring and trending activities and "how" the data collected are evaluated.

The staff finds the applicant's "monitoring and trending" program element to be adequate because:

1. The features of building deformation will be monitored using instruments that are capable of producing repeatable measurements such that building deformation can be adequately trended.

2. The data collected will be compared to the threshold value acceptance criteria (which are developed via a structural evaluation) for each area monitored to ensure that measured values are below the threshold values. In addition, the applicant stated that it will review the rate at which a location is approaching the established limit and take action if the limit is anticipated to be exceeded prior to the next planned inspection.

3. The “parameters monitored or inspected” program element stated “the interval for recording monitoring elements for deformation for each structure can be increased to the interval in the next lower Stage if no change in measurements are observed for 3 years. Stage One structures that have shown no change in deformation for 10 years may increase the inspection interval to once every 5 years. Structures that show no evidence of building deformation will continue to be inspected with a frequency as established by the Structures Monitoring Program. This is adequate because even if inspection frequencies are changed due to lack of or very slow expansion, a (maximum) five-year interval will be consistent with inspection guidelines contained in Chapter 6 of ACI 349.3R-96 and GALL Report recommendations.

Based on its review of the application, as revised by letter dated May 18, 2018, and review of the applicant’s responses to RAIs, the staff confirmed that the “monitoring and trending” program element satisfies the criteria defined in SRP-LR Section A.1.2.3.5; therefore, the staff finds it acceptable.

Acceptance Criteria. LRA Section B.2.1.31B states that as described in the Methodology Document, the threshold factor is the design margin expressed as the amount by which ASR loads can increase beyond currently measured values that are used in the calculations such that the structure or structural component will still meet the allowable limits of the code. Threshold factor is an outcome of the evaluation vice an input to the analysis methodology approach. A unique threshold factor is calculated for each building based on the available margin, and is used to establish threshold limits for structural monitoring parameters.

The LRA states that an administrative limit of 97% of the threshold limit is set for all stages in addition to reductions of 90% and 95% for Stages One and Two threshold limits, respectively. The additional three percent margin plus the reduction to threshold factors for Stage One and Two analyses provide time to perform additional inspections to confirm that the limits are being approached and to initiate corrective actions. When the administrative limits are reached, further structural evaluation in accordance with the Methodology Document will be performed and corrective actions (e.g., re-evaluate structure, structural modification, more frequent monitoring) taken as necessary.

The LRA discusses chemical prestressing due to ASR and the potential for rebar strain. The LRA states that the codes of record combined with the analytical approaches and acceptance criteria described in the Methodology Document ensure that structure behavior remains elastic (under service conditions), as long as ASR-affected structures are monitored against the threshold limits.

The staff reviewed the applicant’s “acceptance criteria” program element against the criteria in SRP-LR Section A.1.2.3.6, which state that the acceptance criteria of the program and its basis should be described. The acceptance criteria should ensure that the intended functions are maintained consistent with all CLB design conditions during the period of extended operation.

The staff finds the applicant’s “acceptance criteria” program element to be adequate because:

1. The Methodology Document, which is the procedural document used to develop acceptance criteria for ASR-affected structures, is found to be an adequate approach that yields acceptance criteria for each parameter monitored for each structure (staff’s detailed review of the Methodology Document is documented in its SE related to LAR 16-03).

2. The acceptance criteria are based on structure-specific analysis and structural evaluations that take into account the design basis for each structure.

3. There are administrative limits that trigger a structural re-evaluation or other corrective action prior to loss of a structure’s intended function.

4. The potential for ASR-induced rebar strains have been taken into account in the structural evaluations in accordance with the Methodology Document, and rebar will remain elastic under service conditions as long as threshold limits and ASR expansion limits have not been exceeded.

Based on its review of the application, as revised by letter dated May 18, 2018, the staff confirmed that the "acceptance review" program element satisfies the criteria defined in SRP-LR Section A.1.2.3.5 and, therefore, the staff finds it acceptable.

Operating Experience. LRA Section B.2.1.31B discusses operating experience related to building deformation. Specifically:

- Building Deformation – Containment Enclosure Building (CEB): In late 2014 a walk down was performed to investigate a concern from the NRC that water was leaking into the Mechanical Penetration area through building seals. The seal was found torn and it was determined that the tear occurred because of relative movement between the Containment Building and the CEB. It was determined through measurements and visual assessments that the CEB experienced outward radial deformation caused by internal in-plane expansion (strain) in the concrete produced by ASR in the CEB and also in the backfill concrete. The applicant's evaluation of the CEB identified different symptoms of building deformation and as a result walk downs were performed to identify these symptoms that may have been missed prior to this discovery.

- Building Deformation – Residual Heat Removal (RHR) Equipment Vault & Fuel Storage Building (FSB): Expansion resulting in building deformation has been observed in the RHR Equipment Vault and FSB. These have been determined to be Stage Three structures. As a result of identified observations, additional monitoring has been established in the RHR (invar rod extensometers, crack gages), and enhanced use of laser measurements is being evaluated for use in FSB.

- Building Deformation – "B" Electrical Tunnel: The applicant evaluated the "B" electrical tunnel using its Methodology Document. Following the methodology, the governing failure mode is out-of-plane shear, however, there are no indications of flexural cracking. As a result, this wall is subject to an enhanced monitoring frequency to detect signs of flexural cracking.

- Building Deformation – Containment Enclosure Ventilation Area (CEVA) North Wall: The CEVA structure exhibits extensive cracking and out-of-plane deformation that is attributed to expansion of the concrete fill behind it. Enhanced monitoring is in effect and plans are in place to perform a structural retrofit.

- Building Deformation – Safety Related Electrical Manholes: Several safety related electrical manholes were analyzed using the Methodology Document and shown not to meet code criteria. The applicant determined that eliminating the possibility of surcharge loading was necessary and will be controlled through physical and administrative controls.

The LRA also includes additional plant-specific Operating Experience related to seismic isolation gaps less than nominal value, misalignment of ducts, and deformed and misaligned flexible couplings.

The LRA states that NextEra Energy will update the AMP for any new plant-specific or industry Operating Experience (OE), including ongoing industry studies and research if applicable. The LRA also states that it submitted a license amendment request in accordance with 10 CFR 50.90 for review and approval, to incorporate a revised methodology related to ASR material properties and building deformation analysis (LAR 16-03).

The staff reviewed this information against the acceptance criteria in SRP-LR Section A.1.2.3.10, which states that consideration of future plant-specific and industry operating experience relating to AMPs should be discussed. The operating experience of AMPs that are existing programs, including past corrective actions resulting in program enhancements or additional programs, should also be considered. For new AMPs that have yet to be implemented, the SRP states that an applicant should commit to a review of future plant-specific and industry operating experience to confirm their effectiveness.

The staff reviewed operating experience information in the application and during the March 19-22, 2018, audit to determine if the applicable aging effects and industry and plant-specific operating experience were reviewed by the applicant. The staff finds the Operating Experience program element acceptable because:

1. Based on its review of the LRA, its onsite review of AMP basis documents, and the corrective action program and implementing procedures reviewed on site, the staff noted that the applicant's program appropriately identifies plant-specific operating experience and has used that operating experience to make necessary adjustments to the program to ensure it continues to manage ASR effects on structural functionality.

2. The program will continue to monitor industry and plant-specific operating experience, including relevant national and international research, and will modify the program as necessary.

Based on its audit and review of the application, the staff finds that operating experience related to the applicant's program demonstrates that it can adequately manage the effects of ASR-related building deformation on SSCs within the scope of the program, and that implementation of the program has resulted in the applicant taking appropriate corrective actions. The staff confirmed that the "operating experience" program element satisfies the criterion in SRP-LR Section A.1.2.3.10.

UFSAR Supplement. LRA Section A.2.1.31B provides the UFSAR supplement for the BDMP. The staff reviewed this UFSAR supplement description of the program against the guidance for a plant-specific program in SRP-LR Table 3.0-1. This guidance states that the program description should contain information associated with the bases for determining that aging effects will be managed during the period of extended operation. In addition, Commitment 71 stated that the applicant will implement the BDMP prior to the period of extended operation. Commitment 91 states that by March 15, 2020, the applicant will:

1. Enhance the Structures Monitoring Program to require structural evaluations be performed on buildings and components affected by deformation as necessary to ensure that the structural function is maintained.

2. Enhance the Building Deformation AMP to include additional parameters to be monitored based on the results of the CEB Root Cause, structural evaluations and walk downs. Additional parameters monitored will include alignment of ducting, conduit and piping, seal integrity, laser target measurements, key seismic gap measurements, and additional instrumentation.

3. Develop a design standard to implement the Building Deformation Program element 3 (Parameters Monitored/Inspected). The design standard will clarify the deformation evaluation process and provide an auditable format to assess it. The design standard will include steps for each of the three evaluation stages that include parameters monitored, basis for why the parameter is monitored, and conditions that prompt actions for the subsequent step.

The staff noted that although the applicant stated that these actions would be completed by March 15, 2020, these activities have already been implemented. The detailed review of Numbers 1 and 3 is documented in the staff's Safety Evaluation related to LAR 16-03, and the detailed review of Number 2 is documented in the staff's review of program elements 3 and 4 above.

The staff determined that the information in the UFSAR supplement is an adequate summary description of the program, as required by 10 CFR 54.21(d) and is, therefore, acceptable.

Conclusion. On the basis of its technical review of the applicant's BDMP, the staff concludes that the applicant demonstrated that, through the use of this AMP, the effects of aging of concrete structures and other components affected primarily by ASR-related building deformation will be adequately managed so that the intended function(s) of the structures under consideration will be maintained consistent with the CLB for the period of extended operation, as required by 10 CFR 54.21(a)(3). The staff also reviewed the UFSAR supplement for this AMP and concludes that it provides an adequate summary description of the program, as required by 10 CFR 54.21(d).