STAFF EVALUATION OF NUCLEAR FUEL SERVICES FACILITY RESPONSE TO GENERIC LETTER 2015-01 "TREATMENT OF NATURAL PHENOMENA HAZARDS IN FUEL CYCLE FACILITIES"

I. Background

On June 22, 2015, the U.S. Nuclear Regulatory Commission (NRC) issued Generic Letter (GL) 2015-01, "Treatment of Natural Phenomena Hazards in Fuel Cycle Facilities" (Agencywide Documents Access and Management System [ADAMS] Accession Number: ML14328A029). The GL was issued for two purposes: (1) to request that addressees submit information to demonstrate compliance with regulatory requirements and applicable license conditions regarding the treatment of natural phenomena events in the facilities' integrated safety analysis (ISA); and (2) to determine if additional NRC regulatory action is necessary to ensure that licensees comply with their licensing basis and existing NRC regulations.

By letter dated October 2, 2015, Nuclear Fuel Services Inc. (NFS) responded to GL 2015-01 (ADAMS Accession Number: ML15289A193). The NRC staff (staff) issued a request for supplemental information on February 8, 2016 (ADAMS Accession Number: ML15348A029) and by letter dated June 8, 2016, NFS provided its response (ADAMS Accession Number: ML16172A098). The staff issued a second request for supplemental information on December 5, 2016 (ADAMS Accession No.: ML16327A038) and by letter dated April 18, 2017, NFS provided its response (ADAMS Accession Number: ML17135A194).

The purpose of this evaluation report is to document the staff's review of NFS's response to GL 2015-01, including its response to the requests for supplemental information and onsite calculations, to determine if NFS adequately addressed the potential effects of natural phenomena hazards (NPH) events in the ISA. The staff selected a subset of NPH using a risk-informed approach to verify that NFS used appropriate methods to evaluate the impacts of NPH in conducting the facility's ISA. The staff did not perform a complete assessment of the ISA for all NPH events nor did it conduct a design certification review for NPH. This method is consistent with NRC guidance in Chapter 3 of NUREG-1520, Revision 2, "Standard Review Plan (SRP) for Fuel Cycle Facilities License Applications." The staff also used Interim Staff Guidance (ISG) Number: FCSE-ISG-15, "Natural Phenomena Hazards in Fuel Cycle Facilities" (ADAMS Accession Number.: ML15121A044) for its review. The staff will perform an inspection using Temporary Instruction (TI) 2600/016, "Inspection Activities Associated with GL 2015-01" (ADAMS Accession No.: ML15317A506) to independently verify that NFS is in compliance with the regulatory requirements and applicable license conditions regarding the treatment of NPH in its ISA. The inspection results from this TI will also be used to follow-up with previously identified Unresolved Items regarding the treatment of NPH and to inform the closure process of NRC GL 2015-01. The results of these regulatory activities will allow the staff to verify that NFS demonstrates compliance with regulatory requirements and applicable license conditions regarding the treatment of NPH at the facility.

The NFS site is located at 1205 Banner Hill Road, within the limits of the City of Erwin in the State of Tennessee. The Protected Area of approximately 18 acres is located within approximately 70 acres of NFS-owned land, the remainder of which is either devoted to vehicle parking areas, is undeveloped, or is undergoing decommissioning. Existing processes at NFS are not required to meet the requirements of 10 CFR Paragraph 70.64(a), "Baseline design criteria" which applies to new facilities or new processes at existing facilities.

Enclosure

II. GL 2015-01 Requested Actions

In the GL, the staff requested that all addressees provide information to verify the assumptions in their facilities' ISAs regarding how each facility provides adequate protection against the occurrence of natural phenomena events. Specifically, the staff asked that addressees take the following actions:

a) Submit definitions of "unlikely," "highly unlikely," and "credible" in evaluating natural phenomena events in the ISA such as earthquakes, tornadoes, tornado missile impacts, floods, hurricanes, and other wind storms. (See Section III.1.0 on page 2).

b) Submit a description of the safety assessment for the licensing and design basis natural phenomena events, including the following information: (See Section III.2.0 on page 3).

   i. likelihood and severity of the natural phenomena events, such as earthquakes, tornadoes, floods, hurricanes, and other wind storms;

   ii. accident sequences as a result of natural phenomena event impacts to facility structures and internal components;

   iii. assessment of the consequences for the accident sequences from item ii that result in intermediate and/or high consequence events; and

   iv. items relied on for safety (IROFS) to prevent or mitigate the consequences of the events from items ii and iii.

c) For facilities subject to 10 CFR Part 70, Subpart H requirements, submit a description of the results of the ISA review used to comply with 10 CFR 70.62(c), identifying the characteristics of the licensing and design basis natural phenomena events applicable to the site, that evaluates possible changes in the methodology, likelihood, and severity of natural phenomena events with those used in the original design/evaluation of the facility. (See Section III.3.0 on page 21).

d) Submit for staff review a summary of the results of any facility assessments or walkdowns, if performed, to identify and address degraded nonconforming, or unanalyzed conditions that can affect the performance of the facility under natural phenomena and have available for NRC inspection the documentation of the qualifications of the team. (See Section III.4.0 on page 21).

III. NFS's Response to GL 2015-01 and Staff Evaluation

1.0 NRC GL 2015-01, Requested Action (1)a: Submit the definitions of "unlikely," "highly unlikely," and "credible" in evaluating natural phenomena events in the ISA such as earthquakes, tornadoes, tornado missile impacts, floods, hurricanes, and other wind storms.

NFS submitted definitions of "unlikely," "highly unlikely," and "credible" that they applied in their ISA. These definitions do not prescribe specific criteria for NPH events. The staff verified that the definitions were consistently applied in the ISA analysis for NPH events. The results of the staff review can be found in Section 2.0 below. Therefore, the staff finds that NFS has adequately responded to GL 2015-01 Requested Action (1)a.

2.0 NRC GL 2015-01 Requested Action (1)b: Submit a description of the safety assessment for the licensing and design basis natural phenomena events, including the following information (See Section III.2.1, III.2.2 and III.2.3):

i. likelihood and severity of the natural phenomena events, such as earthquakes, tornadoes, floods, hurricanes, and other wind storms;

ii. accident sequences as a result of natural phenomena event impacts to facility structures and internal components;

iii. assessment of the consequences for the accident sequences from item ii that result in intermediate and/or high consequence events; and

iv. IROFS to prevent or mitigate the consequences of the events from items ii and iii.

NFS submitted safety assessments for NPH events applicable to their site, including earthquakes, flooding, high winds, tornadoes, and hurricanes. A summary of NFS's assessments and the staff evaluations for selected NPH events are contained below.

2.1 Earthquakes

2.1.1 ISA for Seismic Hazards

NFS provided information regarding implementation of its ISA methodology to determine the need for additional IROFS as a result of seismic induced accident sequences. Specifically, NFS performed a seismic analysis on the structural integrity of the buildings given their construction under the applicable Southern Building Code (SBC). As described in the NFS 2016 ISA Site Summary and its responses to GL-2015-01, the buildings are designed to the applicable SBC for wind and flooding. NFS used the International Building Code (IBC) 2012 and 2015 to re-evaluate the primary building and process equipment ability to withstand earthquakes loads associated with a 2 percent probability of exceedance in 50 years.

For internal components such as process enclosures, process solution columns, process reaction vessels, process storage racks, reagent tanks, and piping, NFS applied a seismic screening methodology to consider new accident sequences and determine the need for new IROFS. The screening methodology separated internal components relevant to accident sequences into two consequence categories: high and intermediate. For those internal components whose damage or failure could result in high consequences, NFS evaluated them under seismic loads associated with a return period of 2,475 years or 2 percent probability of occurrence in 50 years. For internal components whose damage or failure could result in intermediate consequences, NFS evaluated them under seismic loads associated with a return period of 1,000 years or 5 percent probability of occurrence in 50 years. NFS also evaluated current IROFS at loads associated with a 2 percent probability of occurrence in 50 years.

In its response to the staff's request for supplemental information, NFS discussed the results of the screening methodology and concluded that all evaluated internal components and IROFS have sufficient capacity to withstand the seismic loads, as applied. Based on the results of the structural analysis of the building and the seismic screening of the internal components, NFS concluded that there are no new accident sequences and, consequently, no new IROFS to consider within the ISA.

Staff Evaluation:

The staff reviewed NFS's responses and the 2016 ISA Site Summary. Specifically, the staff evaluated NFS's approach for considering seismic events within its ISA and the methodologies applied to determine likelihoods, consequences, and IROFS.

For the structural analysis of the facility NFS used the likelihood of the IBC earthquake which is an earthquake with a probability of exceedance of approximately 4E-4. For the purposes of the ISA, NFS assessed the initiating event frequency of this earthquake as 1E-3 per year. According to NFS's likelihood definitions, NFS designated the likelihood of this event as "unlikely" or "not expected to occur during the plant lifetime." Therefore, the staff agrees that NFS's approach to classify the likelihood of seismic induced events based on the definitions established within its ISA methodology is adequate.

The staff reviewed NFS's approach to determining the consequences of criticality and non-criticality accident sequences. Because NFS determined there were no new seismic induced accident sequences to consider, there were no accident sequences for the staff to assess NFS's approach to determining consequences. However, the staff reviewed the 2016 ISA Summary which describes the general methodology for determining the consequences of accident sequences. Specifically, the staff noted that NFS, consistent with 10 CFR Section 70.61, considers all criticality accident sequences to have high consequences. For radiological consequences, NFS determines the consequences via comparison of postulated releases to the exposure levels cited in 10 CFR 70.61. For chemical consequences, NFS determines consequences via comparison of postulated releases to Emergency Response Planning Guidelines, Acute Exposure Guideline Levels, or Temporary Emergency Exposure Levels, depending on the availability of exposure data. The staff would expect NFS to apply this general methodology to any newly discovered seismic induced accident sequences. The staff will confirm NFS's application of its consequence determination methodology during the TI 2600/016 inspection.

The staff reviewed NFS's approach to identify IROFS required to prevent or mitigate seismic induced accident sequences. Similar to the discussion above regarding consequences, NFS did not identify new accident sequences and, therefore, no new IROFS. However, according to the seismic screening methodology, had NFS identified components that did not have the capacity to withstand the seismic loads as evaluated, NFS would have modified the component to satisfy the applicable building code or analyzed it further through the ISA process to identify IROFS and/or other barriers to satisfy the 10 CFR 70.61 performance criteria. The staff noted that there is the potential for technical deficiencies in this methodology. Specifically, the methodology makes two critical assumptions. One assumption is that the consequences of any discrete non-seismic induced accident bounds the consequences of any credible seismic induced accident which could involve concurrent equipment or administrative control failures. The second assumption is that new accident sequences are possible only if the screening methodology identifies components that do not withstand the evaluation earthquakes. By relying on these assumptions, NFS could potentially exclude details critical to performing an adequate assessment of accident sequences caused by seismic events. This oversight could lead to unanalyzed accident sequences or a misrepresentation of the expected reliability and availability of IROFS to perform their safety function under seismic loads. Given these uncertainties in the seismic screening methodology, the staff will further evaluate NFS's conclusion that there are no new accident sequences or IROFS to consider during the TI 2600/016 inspection.

The staff reviewed NFS's approach to determining whether the IROFS identified adequately prevent or mitigate the seismic induced accident sequences. NFS's response to the staff request for supplemental information (RSI) indicates that no new IROFS were identified during the seismic screening process and that the current internal components and IROFS will survive accelerations associated with 2 percent or 5 percent probability of occurrence in 50 years, depending on the postulated consequences. Given the potential screening deficiencies noted above, the staff will further evaluate NFS's conclusion that the current IROFS are adequate to prevent or mitigate seismic induced accident sequences during the TI 2600/016 inspection.

While noting the potential deficiencies above, the staff agrees that NFS's general methodology to classify the likelihood of seismic induced events, determine the consequences of criticality and non-criticality accident sequences, and identify appropriate IROFS is adequate.

2.1.2 Seismic Evaluation of Building Structures and Equipment

Building Structures:

NFS stated in Section 1.5.2 of its ISA Summary and in Appendix D of its fuel fabrication facility seismic evaluation report, hereafter called seismic report, that NFS buildings at its Erwin site were designed and constructed to comply with the SBC and the IBC criteria for the year of construction. In its seismic report, NFS provided a list of buildings which contain or process radioactive material and are of interest for structural evaluation. NFS also provided the building types and the original date of construction for these buildings. The building types include concrete masonry unit (CMU), reinforced concrete, steel frame, and pre-engineered metal; varying from small, low one-story free standing buildings to multiple attached buildings primarily in the 300 building cluster. Most buildings at the NFS have CMU walls which are either load bearing or non-load bearing wall depending upon the roof support system and direction. Roofs vary from (i) relatively light weight plywood or metal deck topped with insulation and built-up roofing supported by open web joists bearing directly upon the CMU walls to (ii) relatively heavy precast concrete double tees topped with insulation and built-up roofing either bearing directly upon the CMU walls or supported by a system of beams and columns. NFS conducted a site-specific soil characterization study of its Erwin site in 2004 that concluded that the site can be classified as soil site class B. The details of the building structures have been obtained from a combination of original building drawings, various soil reports, other reports, and walk downs. NFS stated that to identify the performance category of the facility, it used two methodologies: (i) the original methodology contained in DOE-STD-1020-2002 and (ii) the newer methodology contained in DOE-STD-1020-2012. Both methodologies determined the facility as an essential facility.

The seismic report stated that several different versions of the SBC were used for the design of the main NFS structures until the issuance of IBC in 2000. The seismic provisions in these codes use a pseudo-static force approach to determine the design seismic base shear that is applied horizontally to the structure. NFS stated that original design calculations were not available for any of its buildings. A seismic reevaluation was performed using the IBC 2012 version that refers to ASCE 7-10 to calculate the base shear of these buildings. An importance factor of 1.5 and site class B criteria were used to obtain the seismic demands.

In 2016, NFS performed a seismic analysis of its main buildings and evaluated selected equipment. The methodology used for structural analysis of the buildings is the equivalent static force method using the seismic base shear calculated by IBC 2012. The IBC 2012 specifies the vertical distribution of the seismic base shear, but since most NFS structures are essentially one-story buildings with most building dead load located at or near the roof, the majority of the seismic base shear was assigned at the roof level. NFS used the finite element code SAP2000 to perform the three-dimensional structural analyses of the buildings. As stated in Section 4.3 of the seismic report, NFS used the deep beam concept of modeling presented in ABK reports where in a low, rectangular building with flat roof and/or interior floors, the roof and floors act as deep beams and transfer the earthquake induced horizontal loads to the building end walls which act as shear walls in transferring the load to the foundation level. In the analysis, the loads were applied to the building models according to the relevant IBC 2012 load combinations for allowable stress. Based on the structural analysis results, NFS concluded that all buildings are stable and not near a collapse state.

Equipment:

By letter dated April 18, 2017 (ADAMS Accession Number: ML17135A194), NFS provided the evaluation of the main processing equipment at the facility. The methodology used for structural analysis of the equipment was based on the requirements of the IBC 2015 and ASCE 7-10. An importance factor of 1.5 and site class B criteria were used to obtain the seismic demands. The methodology uses the equivalent static force method to obtain seismic demands as a percentage of the item weight or based on seismic walk downs to evaluate adequate vertical and horizontal supports of piping. NFS analyzed the following equipment: 1) gloveboxes, 2) storage rockets, 3) storage racks, 4) process columns, 5) natural gas and hydrogen piping; and 6) other process equipment. Based on the results of seismic analyses of the equipment, NFS concluded that all equipment, except for several areas of piping runs, can withstand the seismic demands from an earthquake with a 2 percent probability of exceedance in 50 years. For piping, the seismic walk downs identified several areas in need of improvements of supports. NFS has stated that it plans to complete the improvements in future maintenance shut downs.

Staff Evaluation:

The staff reviewed a sample of the structural analysis of the main NFS facility buildings and evaluation of the equipment and tanks. The staff notes that the original design calculations were not available for the buildings. The staff agrees with the use of criteria of IBC 2012 as an acceptable methodology for the evaluation of earthquake hazards at the facility for the design and construction of the process and storage buildings. The staff reviewed sample building drawings and calculations; discussed those with NFS staff and a consultant; and conducted walk downs of the buildings to ensure that the use of the concept specified in the ABK reports and the use of equivalent static force method are applicable for modeling and conducting analysis for the structures. The use of the risk-targeted ground motions referenced by the IBC 2012 with a 2 percent probability of exceedance in 50 years provides a target risk of seismic induced structural collapse equal to 1 percent in 50 years based on a generic structural fragility. Therefore, the staff concludes that NFS methodology to assess the impact of seismic forces in the primary facility buildings is acceptable and consistent with industry practice. In addition, the staff reviewed drawings and calculations for the seismic evaluation of processing equipment. The staff agrees with NFS methodology to evaluate equipment using the IBC 2015 and seismic walk downs. Based on these reviews, the staff concludes that NFS has adequately modeled and analyzed the buildings and evaluated the equipment and tanks under design basis seismic motion.

2.1.3 Seismically Induced Chemical Consequences

The staff reviewed the NFS evaluation of internal components, including glass columns, presented in its response of April 18, 2017 (ADAMS Accession Number ML17135A194). The NFS evaluation concluded that internal components, including those credited as IROFS, are expected to withstand the evaluation basis earthquake. The staff reviewed the methodology used to evaluate the impacts from seismic loads to processing equipment as described in section 2.1.2 above. The staff agrees with the NFS assessment that the internal processing equipment will be able to withstand the evaluation basis earthquake. As a result, the staff concludes that seismic events are not expected to introduce new accident sequences not previously analyzed in the ISA that could result in intermediate or high acute chemical exposure consequences.

2.1.4 Seismically Induced Criticality

Based on their seismic evaluation, NFS determined that the building would remain intact for the evaluation basis earthquake, which corresponds to an initiating event frequency score of earthquake -4 obtained from the use of earthquake loads with an exceedance probability of 4E-4. In Reference 4, the licensee evaluated all relevant internal components under the seismic loads associated with a 2 percent probability of exceedance in 50 years (evaluation basis earthquake) and determined that no new accident sequences that result in criticality consequences were identified. The internal equipment that NFS evaluated included the solution columns, piping, gloveboxes, and storage racks.

In Reference 1, the licensee identified four scenarios that could credibly lead to criticality. In all cases, the scenarios involve the leak or rupture of process equipment containing uranium solution accumulating in unfavorable geometry (UFG) locations. Criticality is a high-consequence event, and therefore must be “highly unlikely,” which the licensee has defined as having a likelihood index of -4. The initiating event frequency of an earthquake capable of causing process equipment failure was scored at -3, so only a modest reduction in risk from facility design features or conditional probabilities beyond the initiating event frequency is required to meet the performance requirements. In Reference 4, the equipment involved in the scenarios was further evaluated and determined not to fail even during an evaluation basis earthquake.

Criticality in general requires more than a critical mass. Criticality requires a critical mass with sufficient geometry, moderation, and/or other conditions (e.g., reflection) to support a chain reaction. A seismic event does not directly introduce moderator into dry material, so the primary concern is areas where uranium is in solution, such as uranium recovery. All of the licensee’s scenarios involved a spill or leak from piping or process columns. The first scenario, discussed in Section 3.4.1 of Reference 1, involved a leak or rupture of columns containing fissile solutions which spill to the floor. The second scenario, in Section 3.4.2 of Reference 1, involved solution spills into unfavorable-geometry equipment. The third scenario, in Section 3.4.3 of Reference 1, involved solution spills into an unfavorable-geometry ‘dam’ caused by blockages that prevent the solution from spreading out after a spill. The forth scenario, in Section 3.4.4 of Reference 1, involved solution lines adding to the volume of a spill.

Staff Evaluation:

<u>First Scenario: Solution spills to the floor</u>:

This scenario involves the failure of fissile solution-bearing process equipment (e.g., columns). The material at risk is already moderated so the only events necessary for criticality are a seismic-induced failure of the columns and accumulation of solution in an UFG or to an unfavorable depth. The licensee conducted a comparison of the different areas, documented in Appendix G of Reference 1, and concluded that the solvent extraction area bounded the other areas due to the concentration and volume of solution in the area and the limited floor space. After a spill of solution from the favorable geometry columns, the solution would spread out on the floor. The depth of the spill depends on the area it can spread out over and the volume of the spill. The volume of solution available for a spill in solvent extraction is greater than in other areas. While the floor space is less than in other areas and flow paths out of the area (e.g. doorways) are limited, solution leaks are evaluated routinely and protected against in criticality analysis and the ISA. However, the volume of solution that may be spilled in a seismic event can reasonably be expected to exceed that from analyzed process scenarios, because it could involve the common-mode failure of multiple columns. Therefore, this spill scenario is not bounded by existing leakage scenarios documented in the area specific nuclear criticality safety evaluations. However, in NFS's response to an NRC RSI, the licensee further analyzed solution columns and determined that even during the evaluation basis earthquake they would flex at the joints rather than break or leak.

The floors are IROFS that are designed and verified to be flat in order to prevent the accumulation of solution in an UFG collection point. While some disruption of the floor flatness could occur as the result of an earthquake, based on NFS structural analysis, the staff considers it very unlikely that safety significant deviations would occur. In Section 3.2.1 of Reference 1, NFS stated that the floor will deform to match the earth displacement as the seismic wave passes and then return to its normal un-deformed condition. The licensee also stated that the magnitude of the wave displacement is insufficient to crack the concrete floor.

The license performed a series of calculations to determine the subcritical neutron multiplication factor (k_{eff}) of various spill depths and solution concentrations. These calculations used the measured contours of the floor and a conservative amount of solution that would be displaced by equipment to model the spill. For the credible bounding spill concentration the volume equivalent of over 95 percent of the entire solution volume in solvent extraction can be spilled and k_{eff} not exceed the upper subcritical limit (USL). And for the maximum normal solution concentration, more than the total volume of solution can be spilled without exceeding the USL. In Table A-1, "Solvent Extraction Columns," of Reference 1, NFS identifies the columns potentially containing solution. This list includes the condensate columns and other columns which do not normally contain concentrated fissile solution as part of the total volume of solution in solvent extraction room. These columns generally contain liquids with a concentration far less than 1 g ^{235}U/L. If only the columns with concentrated solution spill, the spill volume is bounded by the optimum spill concentration calculation. If all columns spill the resulting concentration and volume are bounded by NFS's 'maximum normal solution concentration' (Case 500-285-2-6-0E) calculation and by the volume of the spill in the calculation. The licensee also noted that rarely under normal operating conditions are all the columns in the Solvent Extraction system simultaneously full of solution, and that the nominal operating capacity of each column is approximately 90-95 percent of the values listed in Table A-1 of NFS report.

These considerations are summarized in the following table:

Event/Condition	Basis
Initiating event frequency score of earthquake that damages equipment: -4	The evaluation basis earthquake, with a return period of 2475 years is not expected to break the columns or cause a leak (Reference 4).
The licensee did not assign a score to these considerations. Instead they simply concluded that the maximum credible spilled solution volume in solvent extraction remains safety subcritical.	Multiple off normal conditions that would have to occur concurrently with the Initiating Event: - Unusually high concentrations in all columns in all stages (e.g., 500 g ^{235}U/L in normally high concentration columns and ~1 g ^{235}U/L in normally low concentration columns), - Maximum possible volumes with all columns full simultaneously, - Further excess volume of solution (~50L).
OR, a failure of the floor IROFS. The floor IROFS is a PEC which is scored as -3.	The floor is verified to be flat and is configuration controlled to prevent the occurrence of UFG collection points. It is not expected to be deformed by an earthquake.

<u>Second Scenario: A piping leak adds to the volume of the spill</u>

This scenario is the same as above, except that it addresses the effect of adding non-fissile liquids from other areas to the spill. The licensee discussed it in Section 3.4.4 of Reference 1. The evaluation in Reference 4 shows that the columns and the piping won't both break in the evaluation basis earthquake.

<u>Third Scenario: Solution sprays into an UFG</u>

The collection of spilled solution into UFG drums, containers, etc., is already discussed in the area specific Nuclear Criticality Safety Evaluations and controls are applied to keep criticality highly unlikely. However, NFS conducted an analysis of items that have the potential to become UFG containers due to earthquakes (e.g., fallen ductwork). This evaluation was documented in Section 3.4.2 of Reference 1.

The licensee evaluated a number of different types of equipment, including ductwork, gloveboxes, light fixtures, and electrical panels. They concluded that gloveboxes would not fail (Reference 4), light fixtures would break if they fell, and electrical panels already have holes (Nuclear Criticality Safety drains) in them to prevent the accumulation of solution. In Reference

1, the licensee considered that ductwork may fall during a less-than-evaluation basis earthquake (i.e., during a -3 earthquake) even though they were constructed in accordance with the Southern Building Code. However, the evaluation in Reference 4 shows that solution bearing columns and piping won't break in the evaluation basis earthquake.

In Reference 1, the licensee analyzed a number of conditional probabilities that would have to happen for a criticality to occur in fallen ductwork. Detailed calculations of the probability of solution spraying into fallen ductwork is documented in Appendix F of Reference 1. The licensee assigned the combination of these conditional probabilities a score of at least -1.

The staff agrees with this assessment of the probability of criticality from solution spraying in to UFG equipment due to an earthquake. This assurance is based on the likelihood of a sufficient earthquake hazard to cause significant equipment damage, the structural analysis of the building, and the conditional likelihoods associated with the earthquake creating an UFG accumulation point, that accumulation point being located near concentrated solution, solution spraying into UFG equipment, and accumulating fissile solution in that equipment to greater than a safe volume. These considerations are summarized in the following table:

Event/Condition	**Basis**
Initiating event frequency score of earthquake that damages equipment/spills solution: -4	The evaluation basis earthquake, with a return period of 2475 years is not expected to break the columns or cause a leak (Reference 4).
Ductwork fails during an earthquake *and* falls to the floor near solution bearing equipment *and* lands in an orientation that creates an UFG.	Most ductwork is not located near columns containing high concentration solution, The duckwork would have to land 'upright' with one open end pointed up and one open end flush against the floor.
The column breaks in such a way that it sprays a stream of solution in the direction of the opening in the fallen duckwork *and* a critical volume of solution accumulates in the fallen ductwork without leaking out the bottom or knocking the ductwork over. The licensee scored these conditional probabilities associated with ductwork falling and solution spraying from columns as being cumulatively worth at least a -1.	Few of the ways a glass column could break would produce a concentrated spray, The spray would have to be in the right direction and the right range (pressure) to land within the open face of the fallen ductwork. This spray would have to then continue to land within the duckwork despite losing pressure, accumulating solution, without the force of the spray knocking the sheet metal duckwork over, and without the solution leaking out the bottom.

<u>Fourth Scenario: Spill forms an UFG due to dam</u>

The collection of spilled solution into UFG due to fallen equipment forming a dam was evaluated by NFS. The licensee's evaluation was documented in Section 3.4.3 of Reference 1.

In the spill scenario, the licensee considered solution spilling to the floor. In this evaluation, the licensee considered that equipment may fall across a doorway. If that happened, the fallen equipment could form a 'dam.' This would cause a more limiting condition than was previously evaluated in the spill scenario above due to the more restricted floor space. The licensee evaluated areas with small floor space and large volumes of solution, and identified two locations with only one door. These doorways were in turn evaluated and the licensee determined that only ductwork was both in position to block the doorways and susceptible to falling during an earthquake. In the Reference 1 evaluation, the licensee considered that ductwork may fall during a less-than-evaluation basis earthquake (i.e., during a -3 earthquake).

The licensee then analyzed a number of conditional probabilities that would have to happen for a criticality to occur due to a dam caused by fallen ductwork. Including the necessary length and orientation of the ductwork section. Licensee walkdowns did not find any large pieces of ductwork/equipment above either rooms ingress/egress locations.

The staff agrees with this assessment of the probability of criticality from spilled solution collecting in an unfavorable geometry due to fallen equipment forming a dam. This assurance is based on the likelihood of a sufficient earthquake hazard to cause significant equipment damage, and the conditional likelihoods associated with the earthquake creating an UFG dam. These considerations are summarized in the following table:

Event/Condition	**Basis**
Initiating event frequency score of earthquake that damages equipment/spills solution: -4	The evaluation basis earthquake, with a return period of 2475 years is not expected to break the columns or cause a leak (Reference 4).
Ductwork fails during an earthquake *and* a large piece falls to the floor where it can block a doorway *and* lands in an orientation that creates an UFG. The licensee scored these conditional probabilities as being cumulatively worth at least a -1.	The ductwork is lightweight and is constructed in accordance with the Southern Building Code and would not likely fail during an earthquake. Licensee walk downs found no large pieces of ductwork near the doorways to the rooms identified as being of concern. The duck work would have to land on its side at the right angle and close enough to the doorway to block flow, while being flush against the floor.

<u>Summary of staff conclusions for seismically induced criticality:</u>

The staff agrees with the licensee that the seismically induced criticality is 'Highly Unlikely' in accordance with 10 CFR 70.61, through crediting the initiating event frequency associated with the evaluation basis earthquake and a variety of conditional probabilities based on the laws of physics and operating characteristics of the facility.

2.1.5 Seismically Induced Fire Consequences

In its response to NRC GL 2015-01, NFS analyzed the fire consequences from a natural phenomenon event. The staff reviewed the analysis performed by NFS in response to GL 2015-01 and the ISA Summary. There are two bounding scenarios involving fire events: a liquid hydrogen supply line break and a natural gas supply line break. In both scenarios, the licensee assumes that the IROFS in place will be adequate to mitigate the consequences during a seismic event. The IROFS in place include passive controls, diking to control the spread of flammable liquids, and 2-hour fire walls. The Seismic Evaluation for NFS indicated that the hydrogen and natural gas piping will not fail, but there are opportunities for improvement in the piping supports. The excess flow valve (FCV-HL01) and flammable gas line supports, specifically those that are credited as the FIRE-5 IROFS, should be inspected during the temporary instruction inspection. The staff finds that the evaluation of the seismic induced fire consequences is adequate.

2.2 Tornadoes

In its 2016 ISA Site Summary, NFS discusses the initiating event frequency of tornadoes and describes data associated with high wind conditions. Specifically, the 2016 ISA Site Summary discusses historical wind speeds and tornado activity in Unicoi County. Since 1950 the highest recorded wind speed was 69 miles per hour, and the strongest tornado was an F-3 on the Fujita tornado scale.

Due to the design of the building, NFS concluded that it is highly unlikely that high winds would result in failures of the building walls or other structural items, causing a release of hazardous material. NFS further concluded that there are no additional high wind accident sequences to consider and, therefore, there are no additional IROFS to apply.

For tornadoes, NFS estimated the likelihood of a tornado strike at the site as 1.692E-5 tornado per year based on historical data. Based on this likelihood, NFS concluded that tornado induced accident sequences are highly unlikely, and therefore, there are no additional IROFS to apply.

Staff Evaluation:

The staff evaluated NFS's approach for considering high wind and tornado induced events within its ISA and the methodologies applied to determine likelihoods, consequences, and IROFS. With respect to determining likelihood, the staff reviewed NFS's likelihood estimation of a tornado strike and the wind speed data from other high wind events. As previously mentioned, according to NFS's likelihood definitions, NFS designated the likelihood of a tornado strike at NFS as "highly unlikely." Based on the data in Appendices A, B, and C of NUREG-CR/4461, Revision 2, the staff agrees that a tornado strike at NFS is highly unlikely and, therefore, agrees that NFS's approach to classify the likelihood of tornado events based on the definitions established within its ISA methodology is adequate.

With respect to high winds, data from the National Centers for Environmental Information Storm Events Database suggest that the likelihood of exposure to winds greater than 60 miles per hour is unlikely. In its 2016 ISA Site Summary and response to GL2015-01, NFS states that the buildings were built to the relevant building codes, "which were sufficient to ensure that the design basis wind, flooding, and seismic events would not cause high or intermediate consequence events other than what was already analyzed." The staff reviewed the design basis for wind speeds in the associated building codes and agrees that damage as a result of high winds is highly unlikely. Although the staff did not perform a review of wind structural calculations, based on the staff's review of the primary building evaluations performed for seismic demands and because the buildings are primarily masonry structures with low height, the staff agrees, using engineering judgement, that the facilities should have sufficient capacity to withstand the wind loads associated to the wind criteria in the building code. Therefore, the staff agrees with NFS's approach for considering high winds and tornadoes in its ISA.

2.3 Other Natural Phenomena Hazards

Similar to its approach for considering seismic activity, high winds, and tornadoes in its ISA, NFS analyzed the potential hazards from floods and lightning.

For floods, as previously mentioned, NFS states in its 2016 ISA Site Summary and its response to GL 2015-01 that NFS is built to withstand the design basis flood. NFS states the northern portion of the site is within the 100-year floodplain and could be subjected to significant flooding. However, the 2016 ISA Site Summary states that the effects of flooding can be mitigated by site features and administrative actions. These features and actions include a security wall that surrounds the site and ample warning to take actions to shut down processing equipment and seal containers. For lightning, NFS considered the potential hazards in accordance with the Lightning Protection Code (NFPA 780) and applied lightning protection.

Staff Evaluation:

The staff reviewed the floodplain data to confirm the potential flood levels. The staff also reviewed supporting documentation to assess the potential effects of and mitigating actions for flooding and lightning.

Based on the design on the buildings, the implementation of lightning protection and the plan to implement emergency procedures, accordingly, the staff agrees with NFS's approach to considering other NPH within its ISA.

3.0 NRC GL 2015-01 Requested Action (1)c: For facilities subject to 10 CFR Part 70, Subpart H requirements, submit a description of the results of the ISA review used to comply with 10 CFR 70.62(c), identifying the characteristics of the licensing and design basis natural phenomena events applicable to the site, that evaluates possible changes in the methodology, likelihood, and severity of natural phenomena events with those used in the original design/evaluation of the facility.

NFS provided in its response to GL 2015-01 the seismic reassessment of the primary building structures and the design basis for other natural phenomena events. The facility was seismically evaluated using the IBC 2012 and 2015 to determine if it meets the current requirements and to identify if it can remain stable and not near collapse. The analysis included a seismic assessment of internal components.

The staff reviewed the seismic analysis and the staff evaluation is included in Section III.2.1 above. Based on this evaluation, the staff finds that NFS has adequately responded to NRC GL 2015-01 Requested Action (1)c.

4.0 NRC GL 2015-01 Requested Action (1)d: Submit for staff review a summary of the results of any facility assessments or walkdowns, if performed, to identify and address degraded, nonconforming, or unanalyzed conditions that can affect the performance of the facility under natural phenomena and have available for NRC inspection the documentation of the qualifications of the team.

NFS stated in its response to GL 2015-01 and technical reports that the facility was reevaluated for earthquake loading and that walkdowns were performed to verify the configuration of the structure as part of developing the analytic model used to assess seismic loads on the facility. The results of the walkdowns were incorporated in the model to assess the performance of the primary building structures.

The staff will inspect the bases, execution, and results of the above mentioned walkdowns during the implementation of TI 2600/016, "Inspection Activities Associated with NRC GL 2015-01," (ADAMS Accession Number ML16293A899). Therefore, the staff finds that NFS has adequately responded to NRC GL 2015-01 Requested Action (1)d.

IV. Conclusion

On the basis of this evaluation, the staff finds that NFS adequately responded to Requested Actions (1)a through (1)d of GL 2015-01. The staff will perform an inspection using TI 2600/016 to independently verify that NFS is in compliance with the regulatory requirements and applicable license conditions regarding the treatment of NPH in its ISA. The results of these regulatory activities will allow the staff to verify that NFS demonstrates compliance with regulatory requirements and applicable license conditions regarding the treatment of NPH's at the facility.

V. References

54T-16-0003, "Nuclear Criticality Safety Analysis for Seismic Events at Nuclear Fuel Services," dated May 17, 2016, Rev. 0.

ANSI/ANS-8.1-2014, "Nuclear Criticality Safety in Operations with Fissionable Materials outside Reactors," dated April 15, 2014.

21G-17-0081, "Response to NRC Second Request for Supplemental Information Regarding the 2015 Nuclear Fuel Services Response to Generic letter 2015-01."

Atkins-NS-TR-NFS-17-01, "Seismic Evaluation of Equipment for Nuclear Fuel Services Fuel Fabrication Facility," dated April 12, 2017, Rev. 1.

ABK Reports, Methodology for Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings, Reports 1 through 8, National Science Foundation, Washington, DC, 1981

DOE. Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities. DOE-STD-1020-2002. Washington, DC: U.S. Department of Energy. January-2002.

DOE. Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities. DOE-STD-1020-2012. Washington, DC: U.S. Department of Energy. December 2012.