UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 28, 2020

Mr. Daniel G. Stoddard
Senior Vice President and
Chief Nuclear Officer
Innsbrook Technical Center
5000 Dominion Boulevard
Glen Allen, VA 23060-6711

SUBJECT: SURRY POWER STATION, UNIT NOS. 1 AND 2 – STAFF ASSESSMENT OF FLOOD HAZARD FOCUSED EVALUATION AND INTEGRATED ASSESSMENT (EPID NO. L-2019-JLD-0008)

Dear Mr. Stoddard:

The purpose of this letter is to document the staff's evaluation of the Surry Power Station, Unit Nos. 1 and 2 (Surry) flooding integrated assessment (IA) which was submitted in response to Near-Term Task Force (NTTF) Recommendation 2.1, "Flooding." The U.S. Nuclear Regulatory Commission (NRC) has concluded that that the results and risk insights described in the Surry flooding IA and the staff's independent assessment support the NRC's determination that no further response or regulatory actions are required.

By letter dated March 12, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340), the NRC issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, under Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f), hereafter referred to as the "50.54(f) letter." The request was issued in connection with implementing lessons learned from the 2011 accident at the Fukushima Dai-ichi nuclear power plant, as documented in the NRC's NTTF report (ADAMS Accession No. ML111861807). Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood hazards for their sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits and combined licenses (ADAMS Accession No. ML12056A046). By letter dated March 12, 2015 (ADAMS Accession No. ML15078A291), Virginia Electric and Power Company (Dominion, the licensee) submitted its flood hazard reevaluation report (FHRR) for Surry.

After reviewing the licensee's FHRR, the NRC staff issued by letter dated February 29, 2016 (ADAMS Accession No. ML16041A341), a summary of its review of the Surry reevaluated flood-causing mechanisms.

Enclosure 1 transmitted herewith contains Security-Related Information and Critical Electric Infrastructure Information (CEII). When separated from Enclosure 1, this document is decontrolled.

The NRC staff also issued a staff assessment by letter dated December 21, 2016 (ADAMS Accession No. ML16323A185), which provided the documentation supporting the NRC staff's conclusions summarized in the letter. These letters affirmed that the local intense precipitation (LIP), failure of dams, and storm surge flood-causing mechanisms at Surry are not bounded by the plant's current design basis, therefore, additional assessments of the flood hazard mechanisms are necessary.

By letter dated October 1, 2019 (ADAMS Accession No. ML19291B034), the licensee submitted its IA for Surry. The IAs are intended for the NRC to assess the site's capability to cope with the reevaluated hazard, and to determine if additional regulatory actions are necessary under the backfit regulation. The purpose of this staff assessment is to provide the results of the NRC's evaluation of the Surry IA.

As set forth in the enclosed staff assessment, the NRC staff has concluded that the Surry IA was performed consistent with the guidance described in Nuclear Energy Institute (NEI) 16-05, Revision 1, "External Flooding Assessment Guidelines" (ADAMS Accession No. ML16165A178), as endorsed by Japan Lessons-Learned Division (JLD) interim staff guidance (ISG) JLD-ISG-2016-01, "Guidance for Activities Related to Near-Term Task Force Recommendation 2.1, Flood Hazard Reevaluation" (ADAMS Accession No. ML16162A301).

The NRC staff has also concluded that the licensee has demonstrated that effective flood protection, if appropriately implemented, exists for the LIP and dam failure flood-causing mechanisms, and that the site is reasonably protected against these flood hazards. In addition, the staff has determined that the licensee has adequately evaluated the storm surge flood hazard. This determination is primarily based on the following considerations:

1. The probabilistic hazard evaluation determined a low event probability,

2. The licensee's anticipatory actions provide effective flood protection, and the reactive actions provide reliable flood mitigation, and

3. The identification of a) the remaining actions to be completed, and b) maintaining the strategy to address the reevaluated storm surge event as regulatory commitments included in the IA.

The staff has inspected, audited, and reviewed, as appropriate, pertinent provisions of the licensee's strategy and found it acceptable. The NRC staff expects that the licensee will address the regulatory commitments consistent with NEI 99-04, "Guidelines for Managing NRC Commitment Changes," Revision 0, dated July 1999 (ADAMS Accession No. ML003680088). Based on the above, the NRC staff concludes that no additional regulatory actions are necessary.

If you have any questions, please contact Juan Uribe at 301-415-3809, or by e-mail at Juan.Uribe@nrc.gov.

Sincerely,

/RA/

Mohamed K. Shams, Deputy Director
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos: 50-280 and 50-281

Enclosures:
1. Staff Assessment Related to the Flooding Evaluations for Surry (non-public)
2. Staff Assessment Related to the Flooding Evaluations for Surry (public)

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SUBJECT: SURRY POWER STATION, UNIT NOS. 1 AND 2 – STAFF ASSESSMENT OF FLOOD HAZARD FOCUSED EVALUATION AND INTEGRATED ASSESSMENT DATED MAY 28, 2020

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DATE	3/15/2020	3/16/2020	2/2/2020	4/14/2020
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DATE	4/23/2020	5/18/2020	5/1/2020	5/28/2020

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STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO THE FOCUSED EVALUATION AND INTEGRATED ASSESSMENT

FOR SURRY POWER STATION, UNIT NOS. 1 AND 2

AS A RESULT OF THE REEVALUATED FLOODING HAZARD

NEAR-TERM TASK FORCE RECOMMENDATION 2.1 - FLOODING

EPID NO. L-2019-JLD-0008

1.0 INTRODUCTION

By letter dated March 12, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340), the U.S. Nuclear Regulatory Commission (NRC) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, under Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f), hereafter referred to as the "50.54(f) letter." The request was issued in connection with implementing lessons learned from the 2011 accident at the Fukushima Dai-ichi nuclear power plant, as documented in the NRC's Near-Term Task Force (NTTF) report (ADAMS Accession No. ML111861807).

Enclosure 2 of the 50.54(f) letter requested that licensees reevaluate flood hazards for their respective sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits and combined licenses (ADAMS Accession No. ML12056A046). If the reevaluated hazard for any flood-causing mechanism is not bounded by the plant's current design basis (CDB) flood hazard, an additional assessment of plant response would be necessary. Specifically, the 50.54(f) letter states that an integrated assessment (IA) should be submitted, and described the information that the IA should contain. By letter dated November 30, 2012 (ADAMS Accession No. ML12311A214), the NRC staff issued Japan Lessons-Learned Project Directorate (JLD) interim staff guidance (ISG) JLD-ISG-2012-05, "Guidance for Performing the Integrated Assessment for External Flooding."

On June 30, 2015 (ADAMS Accession No. ML15153A104), the NRC staff issued COMSECY-15-0019, describing the closure plan for the reevaluation of flooding hazards for operating nuclear power plants. The Commission approved the closure plan on July 28, 2015 (ADAMS Accession No. ML15209A682). COMSECY-15-0019 outlines a revised process for addressing cases in which the reevaluated flood hazard is not bounded by the plant's CDB. The revised process describes a graded approach in which licensees with hazards exceeding their CDB flood may not be required to complete an IA, but instead may perform a focused evaluation (FE). By letter dated September 1, 2015 (ADAMS Accession No. ML15174A257), the NRC informed all affected licensees of the plan to use a graded approach in addressing the reevaluated flood hazard.

Nuclear Energy Institute (NEI) 16-05, Revision 1, "External Flooding Assessment Guidelines" (ADAMS Accession No. ML16165A178), was issued by NEI to describe a method of applying a

Enclosure 2

graded approach to address the reevaluated flood hazards. It has been endorsed by the NRC as an appropriate methodology for licensees to use in response to the 50.54(f) letter. The NRC's endorsement of NEI 16-05, including exceptions, clarifications, and additions, is described in NRC JLD-ISG-2016-01, "Guidance for Activities Related to Near-Term Task Force Recommendation 2.1, Flood Hazard Reevaluation" (ADAMS Accession No. ML16162A301). Therefore, NEI 16-05, Revision 1, as endorsed, describes acceptable methods for Surry Power Station, Unit Nos. 1 and 2 (Surry) to address their response to the reevaluated flood hazard mechanisms.

The NRC staff described how the licensee's assessment of the reevaluated hazard would be reviewed to determine if further regulatory action should be taken, such as backfitting additional safety enhancements, in an internal memorandum dated September 21, 2016 (ADAMS Accession No. ML16237A103), which was revised by memorandum dated March 2, 2020 (ADAMS Accession No. ML20043D958). This memorandum describes the formation of a Senior Management Review Panel (SMRP) from the Office of Nuclear Reactor Regulation that are expected to reach a decision for each plant submitting an IA. Flood hazards evaluated as FEs are not subject to the SMRP. The SMRP is supported by NRC technical staff who are responsible for consolidating relevant information and developing recommendations for the consideration of the panel. In presenting recommendations to the SMRP, the supporting technical staff is expected to recommend placement of each flooding IA plant into one of three groups:

1) **Group 1** will include plants for which available information indicates that further regulatory action is not warranted. For flooding hazards, Group 1 will include plants that have demonstrated (1) effective protection for severe flood hazards, and (2) that consequential flooding is expected to occur only for hazards with a sufficiently small mean annual frequency of exceedance.

2) **Group 2** will include plants for which further regulatory action should be considered under the NRC's backfit provisions. This group may include plants that are unable to protect against relatively frequent flood hazards such that the event frequency in combination with other factors result in a risk to public health and safety for which a regulatory action is expected to provide a substantial safety enhancement.

3) **Group 3** will include plants for which further regulatory action may be needed, but for which more thorough consideration of both qualitative and quantitative risk insights is needed before determining whether a formal backfit analysis is warranted.

The evaluation process that was performed to provide the basis for the staff's grouping recommendation to the SMRP for Surry is described below. Based on its evaluation, the staff recommended to the SMRP that Surry be classified as a Group 1 plant and therefore, no further regulatory action was warranted.

2.0 <u>BACKGROUND</u>

This document provides the final NRC staff assessment associated with the information that the licensee provided in response to the reevaluated flooding hazard portion of the 50.54(f) letter. Therefore, this background section includes a summary description of the reevaluated flood information provided by the licensee and the associated assessments performed by the NRC staff. The reevaluated flood information includes: 1) the flood hazard reevaluation report (FHRR); 2) the mitigation strategies assessment (MSA); and 3) the IA.

Flood Hazard Reevaluation Report

By letter dated March 12, 2015 (ADAMS Accession No. ML15078A291), Virginia Electric and Power Company, doing business as Dominion Energy Virginia (Dominion, the licensee) submitted its FHRR for Surry. On February 29, 2016 (ADAMS Accession No. ML16041A341), the NRC staff issued an interim staff response (ISR) letter for Surry. For Surry, the mechanisms listed as not bounded by the CDB in the ISR letter are local intense precipitation (LIP), failure of dams (intake canal), and storm surge. By letter dated December 21, 2016 (ADAMS Accession No. ML16323A185), the NRC staff issued an FHRR staff assessment, which provided the documentation supporting the NRC staff's conclusions summarized in the ISR letter.

Mitigation Strategies Assessment

By letter dated January 27, 2017 (ADAMS Accession No. ML17033A162, non-public), the licensee submitted the flooding MSA for Surry for review by the NRC staff. The MSAs were intended to confirm that licensees had adequately addressed the reevaluated flooding hazards within their mitigating strategies for beyond-design-basis external events that were put in place to meet NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession No. ML12054A735).

By letter dated January 25, 2016 (ADAMS Accession No. ML16033A353), Dominion submitted a compliance letter and Final Integrated Plan (FIP) in response to Order EA-12-049. The NRC staff's safety evaluation for the licensee's compliance plans for Order EA-12-049 was issued on August 4, 2016 (ADAMS Accession No. ML16158A432). By letter dated October 25, 2017 (ADAMS Accession No. ML17236A437), the NRC staff issued its assessment of the Surry MSA.

The licensee determined in its January 27, 2017, MSA that the reevaluated storm surge event did not impact the FLEX mitigating strategies based on site grade and the location of equipment relied upon as part of the FLEX strategy. For the reevaluated LIP and dam failure flood mechanisms, the licensee identified several modifications needed to the existing FLEX strategies in order to address the reevaluated hazards. The licensee also stated that the development and implementation of the strategies would be in accordance with the Mitigating Beyond Design Basis Event (MBDBE) rule. The staff found the licensee's MSA approach acceptable as documented in the October 25, 2017, letter.

In SECY-16-0142, "Draft Final Rule – Mitigation of Beyond-Design-Basis Events (RIN 3150-AJ49)," (ADAMS Accession No. ML16291A186) provisions were proposed that would have required mitigation strategies to address the reevaluated flood hazard information on a generic basis. As reflected in the Affirmation Notice and Staff Requirements Memorandum (SRM) dated January 24, 2019, the Commission determined that sites addressing the reevaluated hazards on a generic basis was not needed for adequate protection of public health and safety but should instead be assessed on a plant-specific, case-by-case basis under the requirements of 10 CFR § 50.109, "Backfitting," and § 52.98, "Finality of combined licenses; information requests."

The Commission directed in the Affirmation Notice and SRM dated January 24, 2019 (ADAMS Accession No. ML19023A038), that the staff use the 50.54(f) process to ensure that the NRC and its licensees will take the needed actions, if any, to ensure there is no undue risk to public health and safety due to the potential effects of the reevaluated flood hazards. The SRM further directs that the staff should continue these efforts, utilizing existing agency processes to determine whether an operating power reactor license should be modified, suspended, or revoked in light of the reevaluated hazard.

By letter dated August 20, 2019 (ADAMS Accession No. ML19067A247), the NRC staff provided a path forward to treat the reevaluation of flood hazards in light of the Commission's direction in the January 24, 2019, Affirmation Notice and SRM. The staff assessment documented in this letter was performed in accordance with the information in the August 20, 2019, staff letter including a plant-specific determination on whether additional regulatory actions are warranted to address the reevaluated hazard. The staff's evaluation of the IA considers, as appropriate, the licensee's intention to use FLEX equipment to address the reevaluated hazards in accordance with the Commission's direction.

<u>Integrated Assessment</u>

By letter dated October 1, 2019 (ADAMS Accession No. ML19291B034), the licensee submitted the IA for Surry. The IAs are intended for the NRC to assess the site's capability to cope with the reevaluated flood hazard and to determine if additional regulatory actions are necessary. These regulatory actions would be taken in accordance with 10 CFR 50.109, "Backfitting." To facilitate its review of the IA, the NRC staff issued a generic audit plan by letter dated July 18, 2017 (ADAMS Accession No. ML17192A452), stating its intention to review additional relevant information and supporting documentation, as needed. The purpose of this letter is to document the staff's evaluation of the Surry flooding IA.

3.0 <u>TECHNICAL EVALUATION</u>

Surry is located in Surry County, Virginia, on a peninsula which is bordered by the James River on either side. The main hydrologic feature is the James River which is formed by the junction of the Cowpasture and Jackson Rivers in Botetourt County, Virginia, and flows easterly 340 miles before emptying into Hampton Roads at Newport News, Virginia. The site is approximately 7 miles south of colonial Williamsburg, and 8 miles east north east of the town of Surry. The ground surface at the site is generally flat, with steep banks sloping down to the river. Site grade has been established at an elevation of 26.5 feet (ft.) above the U.S. Coast and Geologic Survey mean sea level (MSL) datum at Hampton Roads, Virginia.

The mechanisms listed as not bounded by the CDB in the ISR letter are LIP, failure of dams, and storm surge. Table 3-1 of this report provides a summary of the ISR letter and compares each unbounded hazard analyzed in this assessment against the CDB values.

Table 3-1 Comparison of Unbounded Reevaluated Hazards Against the CDB Hazards for Surry (based on ISR letter).

	Mechanism	**Current Design Basis Elevation (MSL)**			**Reevaluated Hazard Elevation (MSL)**		
		Stillwater	Waves/Runup	Total Elev.	Stillwater	Waves/Runup	Total Elev.
	LIP	Not included in DB	Not included in DB	Not included in DB	29.4 ft.	minimal	29.4 ft.
(CEII)	Dam Failure (intake canal)	No Impact Identified	No Impact Identified	No Impact Identified	**[ ]]**	minimal	**[[ ]]**
	Storm Surge	22.7 ft. (west) 22.7 ft. (east)	1.3 ft. 5.9 ft.	24 ft. 28.6 ft.	24.2 ft. (west) 24.2 ft. (east)	Minimal 14.6 ft.	24.2 ft. 38.8 ft

The guidance described in NEI 16-05, Revision 1, provides methods for demonstrating the adequacy of the existing plant design and mitigating strategies for responding to the reevaluated flooding hazards that exceed a facility's design basis flood level. For Surry, the licensee evaluated LIP under path 3 of NEI 16-05, which intends to demonstrate a feasible response against the hazard exceedance, and leverage the use of mitigating strategies as part of the site response. For the dam (intake canal) failure event, the licensee evaluated the hazard under path 2 of NEI 16-05, which intends to demonstrate effective flood protection against the hazard exceedance(s). In the October 1, 2019, submittal, the licensee concluded that the strategies for maintaining the key safety functions (KSFs) of core cooling, spent fuel cooling, and containment integrity are maintained for these two flood hazards. The licensee's evaluation for these hazards followed the FE process, and are therefore not subject to further evaluation from the SMRP.

For storm surge, the licensee evaluated the flood mechanism under path 4 of NEI 16-05, which intends to demonstrate an effective flood mitigation strategy that relies on existing plant systems, structures, and components (SSCs), mitigation equipment, and manual actions to maintain or restore KSFs. In its October 1, 2019, submittal, the licensee concluded that the site has appropriately addressed the hazard vulnerabilities and will not require additional safety enhancements given that the mitigating strategies in place remain feasible. The licensee's evaluation for this hazard followed the IA process, and is therefore subject to further evaluation from the SMRP. Additional technical details, as well as the NRC staff's review and conclusions for each unbounded flood hazard are provided in the following sections.

3.1 Local Intense Precipitation

At Surry, the licensee stated that the reevaluated LIP event (29.4 ft.) exceeds the site grade (26.5 ft.) and several doorways of key locations. As a result, floodwaters can potentially reach susceptible SSCs that provide KSFs and are located in lower elevations of these locations. Examples of potentially impacted equipment include the emergency diesel generators (EDGs), emergency switchgear room (including the battery rooms), and the emergency power distribution system. Inundation of the switchyard and loss of the EDGs is conservatively assumed to result in an extended loss of alternating current (ac) power (ELAP) event at the site. The complete list of impacted locations as a result of LIP was documented in Dominion Engineering Technical Evaluation (ETE), ETE-SU-2016-0037, Rev. 0, "Surry Power Station Beyond Design Basis (BDB) Flooding Location Intense Precipitation (LIP) Assessment Evaluations," which was performed by the licensee consistent with fleet administrative procedure CM-AA-BDB-103, Revision 0, "Evaluation of Flood Protection Features and Systems."

In addition to the impacted SSCs, mitigating strategies developed under Order EA-12-049 could also be potentially impacted by the reevaluated LIP event. In the Surry MSA, the licensee concluded that the reevaluated LIP flood hazard would potentially threaten the ability of operators to access the main steam valve house (MSVH) at each unit and locally throttle the auxiliary feedwater flow (AFW) in time to prevent overfilling of the steam generators. The FLEX mitigating strategy at Surry requires that operators depart the main control room (MCR) within 20 minutes of the start of the ELAP event, and locally throttle AFW flow in the MSVH within 90 minutes after the start of the event. In order to address the hazard exceedances, the licensee proposed several modifications to the existing FLEX strategy in the MSA, such as 1) installation of seals in unprotected penetrations; 2) calling two additional operators to the site and stationing one in each MSVH prior to the onset of the LIP, and 3) revising the station abnormal weather procedure(s) to include severe weather monitoring and action triggers that would direct the installation of additional flood protection features. Finally, the licensee stated in its MSA that the modifications would be implemented in accordance with the proposed NRC rule for mitigating beyond design basis events.

The NRC staff confirmed that no changes and/or hazard refinements had been made in the FE to the reevaluated LIP hazard floodwater elevations previously reviewed by the staff. This includes no changes to the assumptions, inputs, and methods used to develop the hazard; and the evaluation of associated effects and the flood event duration that was documented in the MSA staff assessment. As a result, no changes to flooding elevations were identified in the FE that would impact any of the FLEX storage location(s), any staging areas, haul paths, connection points, activities, timelines, etc., that had been previously evaluated by the NRC in the MSA review. Therefore, the staff's review of the FE focused on changes to the mitigation response strategy, if any; the implementation status of the proposed actions described in the MSA and also credited in the FE; and the licensee's plan for maintaining these actions at the site.

The licensee's feasible mitigation strategy in the FE for LIP relies on two parallel paths: 1) enhancing the permanently installed flood protection at the site, and 2) implementing procedural changes that incorporate weather monitoring and action-trigger conditions, that lead to the installation of additional temporary flood protection capabilities.

3.1.1 Enhancement of Permanently Installed Flood Protection Features

Permanently installed barriers at Surry, which are relied upon for flood protection are mainly passive components, such as water-tight seals in penetrations, conduits, and duct lines between structures (e.g., manholes, drains, electrical penetrations, etc.) and physical flood barriers (e.g., watertight doors, metal gates, concrete curbs, etc.).

The NRC staff notes that the licensee had previously evaluated the condition of conduit and penetration seals against the flooding CDB as part of NTTF Recommendation 2.3 “Walkdowns” of the 50.54(f) letter, where a total of 78 flood protection features were evaluated. In the staff assessment to the walkdown report (ADAMS Accession No. ML14162A577), the NRC acknowledged that the licensee had completed programmatic controls for periodic inspections of conduit and penetrations seals against the CDB by December 31, 2013.

As part of the 50.54(f) letter activities, the licensee evaluated approximately 1,578 flood features at Surry. The licensee first identified and documented all the flooding features available at the site, including locations with susceptible seals, in Dominion Engineering Technical Evaluation, ETE-SU-2014-0001, Rev. 1, "Conduit/Piping Penetrations and Flood Protection Features Identification." Then, the licensee compared the existing flood protection at the site against the reevaluated LIP flood hazard, in order to identify what changes, if any, needed to be made to existing SSCs that provide KSFs. The licensee documented the results of its evaluation in ETE-SU-2016-0037, Rev. 0, "Surry Power Station Beyond Design Basis (BDB) Flooding Location Intense Precipitation (LIP) Assessment Evaluations.

As part of its review (and consistent with the July 18, 2017, audit plan) the NRC staff audited and reviewed both licensee evaluations. In summary, the staff found that approximately 34 modifications at 12 separate structures have been identified as locations where additional flood protection and/or penetrations seals will be installed. These are:

- Auxiliary Building (2 modifications)
- Boron Recovery and Waste Gas Pump House (1 modification)
- Decontamination Building (3 modifications)
- Fuel Building (1 modification)
- Fuel Oil Pump House (2 modifications)
- Miscellaneous Yard Structures (1 modification)
- New Radwaste Facility (1 modification)
- Service Building - east of the Control Room (4 modifications)
- Service Building - west of the Control Room (13 modifications)
- Unit 1 Containment Spray Pump House (1 modification)
- Unit 2 Containment Spray Pump House (1 modification)
- Turbine Building (4 modifications)

The complete list of structures evaluated, and the modifications proposed at each location are described in detail in licensee document ETE-SU-2016-0037.

<u>Available Physical Margin (APM)</u>

The licensee stated in its FE, that the minimum height of the flood features that are planned or in-progress at the site would be at least one inch higher than the maximum LIP stillwater elevation of 29.4 ft. MSL. The guidance described in NEI 16-05, Revision 1, Appendix B, as endorsed, states that “Negligible or zero APM can be justified as acceptable if the use of conservative inputs, assumptions, and/or methods in the flood hazard reevaluation can be established.”

In the ISR letter, the NRC staff had previously concluded that the licensee's reevaluated flood hazard information was determined using conservative inputs, assumptions, and/or methods, and is a suitable input for other assessments associated with Near-Term Task Force Recommendation 2.1 "Flooding." As previously described in this staff assessment, the LIP flood hazard was not revised in the FE. The licensee stated in its FE that additional measures will be in place at the site to ensure adequate APM for the flood protection features relied upon for a LIP event. These are:

- Doors credited for flood protection will remain closed during and following the LIP event, until flood waters subside,
- Seals for flood boundary penetrations will be periodically verified in place and maintained,
- Walls credited for flood protection (e.g., reinforced concrete, block, and steel walls) are controlled and maintained in accordance with appropriate station procedures,
- Roofs and roofing systems credited for flood protection are controlled and maintained in accordance with appropriate station procedures,
- Roof penetrations are designed, modified and maintained to elevations that prevent LIP flood water from challenging key SSCs,
- Analyzed yard flow paths are controlled (i.e., not blocked or modified without evaluation) in accordance with Dominion Nuclear Fleet Administrative Procedure, MA-AA-113, "Yard Control."

Given the infrequent nature of the LIP event analyzed by the licensee, the conservatisms inherently embedded in the LIP analysis, and the physical margin of at least one inch (or more) of the proposed flood protection barriers above the still water elevations, the NRC staff agrees that there is sufficient APM such that the flood protection barriers, if implemented as described, are reasonably protected against the LIP hazard event.

Reliability of Flood Protection Features

In its FE, the licensee stated that flood protection barriers will be designed to conform to accepted engineering practices. In addition, conservative assumptions (e.g., active and passive drainage structures at the site are considered non-operational, and the flood contributory areas are impervious) were also used to justify acceptable APM. The licensee stated that flood feature reliability will be measured and validated through appropriate training and maintenance activities, field-testing, and analysis. Installation requirements will be added to the station procedures (i.e., 0-0P-ZZ-021, "Severe Weather Preparation," and 0-AP-37.01, "Abnormal Environmental Conditions," and/or equivalent (or new) procedure(s).

The NRC staff notes that the flood protection features proposed at the site have not yet been installed, and as a result, were not reviewed in detail by the NRC staff. However, the licensee indicated in its FE that the station design process described in Dominion Nuclear Standard, DNES-AA-GN-1003, "Design Effects and Considerations," will be used to ensure that any design changes consider the impact(s) of potential flooding events, and whether the activity impacts any of the site's hazard evaluations or existing protective features.

The NRC staff agrees that this approach is consistent with the guidance described in NEI 16-05, Revision 1, Appendix B, Section B.2.3 associated with the implementation of additional temporary and/or permanent flood protection features. In addition, the staff agrees that this programmatic review ensures that the CDB configuration will be maintained with adequate APM and reliability of flood protection features for future design changes.

In its FE, the licensee provided a regulatory commitment to complete the design and installation of the penetration seals and flood protection barriers by the end of the second refueling outage for each unit (after NRC approval of the Surry FE). The NRC staff agrees that the approach to provide a regulatory commitment is consistent with the guidance described in several NRC documents. For example:

- COMSECY-15-0019 "describes that "licensees will submit letters providing a summary of the evaluation and, if needed, *regulatory commitments* to implement and maintain appropriate programmatic, procedural or plant modifications to protect against the LIP hazard." The Commission approved the closure plan on July 28, 2015 (ADAMS Accession No. ML15209A682).

- By letter dated September 1, 2015, the NRC staff issued a letter titled "Coordination of Requests for Information Regarding Flooding Hazard Reevaluations and Mitigating Strategies for Beyond-Design-Basis External Events." This letter describes a graded approach to complete the actions associated with the 50.54(f) letter. Specifically, this letter stated that for plants screening out of an integrated assessment, "Where additional measures are necessary to protect against a flooding mechanism, licensees may include in their submittals *regulatory commitments* to implement procedural or hardware changes."

- By letter dated September 21, 2016 (ADAMS Accession No. ML16237A103), the NRC staff issued the Phase 2 decision making guidance document "Regulatory Decision-making for Reevaluated Flooding and Seismic Hazards for Operating Nuclear Power Plants." The guidance described that the "integrated assessment submittals will include evaluations related to various flooding mechanisms, an estimated timeline and associated time sensitive actions, descriptions of existing capabilities to deal with the scenarios, and possible *regulatory commitments* for new or enhanced capabilities."

As a result of the licensee having identified the proposed actions and modifications as regulatory commitments, the NRC staff appropriately credited the proposed changes that Dominion has planned or implemented at the site as part of its review. The NRC staff expects that the licensee will address the regulatory commitments consistent with NEI 99-04, "Guidelines for Managing NRC Commitment Changes," Revision 0, dated July 1999 (ADAMS Accession No. ML003680088).

3.1.2 Procedural Changes Related to Weather Monitoring and Trigger Actions

The general site response against the reevaluated LIP event at Surry relies on the advanced monitoring of forecasted weather conditions, and the development of new action triggers that direct plant personnel to install additional food protection barriers at SSCs that provide KSFs. Additional details for each area are described below.

Monitoring Weather Conditions

The weather alerts/warnings that may impact the site originate from several sources that are continually monitored, such as the National Weather Service located in Wakefield, VA (staffed continuously), the Dominion Weather Center, and/or the National Oceanic and Atmospheric Administration (NOAA) website. At Surry, the Shift Technical Advisor (STA) has responsibility of monitoring the weather. Any decisions for declaration of the monitoring and action triggers will be based on the information received from monitoring the weather forecasts. In addition, the STA also has the responsibility of reporting the potential of adverse weather conditions to the Shift Manager at every shift turnover briefing. The NRC staff notes that full details of the STA's roles and responsibilities are described in Dominion Nuclear Fleet Administrative Procedure, OP-SU-501, "Duties of the Shift Technical Advisor."

The NRC staff used the guidance described in NEI 16-05, Revision 1, Appendix C, Section C.5.1 and finds the monitoring approach acceptable because it is an institutionalized and objective-based procedure that responds to actual or predicted flood conditions or effects. Furthermore, the weather warning and/or alert monitoring established at Surry is expected to be reliable because the information will likely originate from a trusted government agency's forecast.

The next step in the site's response strategy is to use the weather information described above and compare it against established anticipatory strategies to address a flood prior to it affecting the plant. There are two primary procedures relied upon during a LIP event which will be revised to incorporate the revised monitoring and action triggers. These procedures are:

- Surry Power Station Operating Procedure SU-PROC-000-0-0P-ZZ-021, "Severe Weather Preparation," and

- Surry Power Station Abnormal Procedure, 0-AP-37.01, "Abnormal Environmental Conditions."

The anticipatory strategies that will be incorporated in these procedures will allow the site to be protected from the reevaluated LIP flood hazard such that flooding of the SSCs that protect/provide KSFs is not expected. As a result, an ELAP cannot be caused by the reevaluated LIP flood hazard. For example, at certain locations like the Fuel Oil Pump House, barriers were credited and assumed to be in place prior to the occurrence of consequential flood levels, and were confirmed to provide the required flood protection for the site-specific LIP storm. The licensee further noted that temporary flood protection measures are to be implemented at the site in accordance with station design change DC SU-15-01084, "BDB Flood Barriers."

In its FE, the licensee also provided several regulatory commitments associated with the revision of these procedures. In its FE, the licensee committed to:

- Develop and/or update applicable Station and Dominion Energy fleet procedures to provide appropriate guidance to station personnel, and

- Provide training to station personnel in order to understand and implement the appropriate response and actions.

The regulatory commitments are expected to be implemented by the end of the second refueling outage for each unit (after NRC approval of the Surry FE). As a result of the licensee having identified the proposed actions and modifications as regulatory commitments, the NRC staff appropriately credited the proposed changes that Dominion has planned or implemented at the site as part of its review. The NRC staff expects that the licensee will address the regulatory commitments consistent with NEI 99-04, "Guidelines for Managing NRC Commitment Changes," Revision 0, dated July 1999 (ADAMS Accession No. ML003680088).

Development of Revised Action Triggers

The licensee calculated the monitoring and trigger conditions appropriate for the site in Bechtel Calculation 25786-000-HOC-HY00-00001, Rev. 000, "Surry Power Station Local Intense Precipitation (LIP) Monitoring and Trigger Determination." As part of its review (and consistent with the July 18, 2017, audit plan) the NRC staff audited this calculation. In summary, the following monitoring/action triggers will be implemented at the site:

- The 48-hour monitoring trigger will be initiated if a precipitation depth of 4.0 inches or more in a 6-hour duration is predicted during the next 48 hours. At this time the site will begin monitoring weather forecasts as often as they are released, and put the site on alert as to the potential for installing the action trigger-initiated LIP flood barriers within the next 48 hours. Contact between the Dominion Weather Center and the site will be initiated. The site will ensure that the LIP flood barriers are available and ready for installation.

- The 24-hour monitoring/action trigger to assess and augment personnel at the site will be initiated, if necessary, if a precipitation depth of 4.0 inches or more within a 6-hour duration is predicted during the next 24 hours.

- The 12-hour action trigger to install and inspect flood protection features will be initiated if a precipitation event with a depth of 4.0 or more inches within a 6-hour duration is predicted in the next 12 hours.

During the audit, the NRC staff asked the licensee to clarify if the mode of operation had any impact on the monitoring/action triggers described, such that the plant may be directed to shut down if operating at full power. In its response, the licensee clarified that based on the site's credited flood protection measures, the licensee will not direct operators to shut down the plant regardless of mode of operation.

The licensee also stated that additional information regarding the different modes of operation is described in licensee reference ETE-SU-2016-0037. The NRC staff confirmed that licensee procedure ETE-SU-2016-0037 is applicable to all modes of plant operations.

Time Sensitive Actions (TSAs)

Guidance document NEI 12-06, Revision 4 “Diverse and Flexible Coping Strategies (FLEX) Implementation Guide,” (ADAMS Accession No. ML16354B421) defines TSAs as: “Tasks, manual actions or decisions that are identified as having Time Constraints.” In its FE, the licensee stated that the TSAs at Surry are the procedural steps for installation of the flood barriers. The TSA actions, which are expected to require no more than 6 hours to be performed, are to be initiated 12 hours prior to a forecasted LIP event of 4 inches or more within a 6-hour period (the LIP action trigger).

In general, the validation of TSAs is achieved in a two-step process: verification and validation of activities. Verification occurs prior to validation, and refers to the systematic verification of equipment capability and performance, equipment connections, tooling, plant modifications, and procedures/guidelines. Those activities are expected to be accomplished as part of the existing licensee processes such as the design change process, procurement process or procedure/guideline development process. At Surry, the licensee will accomplish this step by relying on several procedures that will be revised, such as SU-PROC-000-0-0P-ZZ-021, "Severe Weather Preparation," and 0-AP-37.01, "Abnormal Environmental Conditions."

Validation activities refers to validation of the feasibility of individual strategies identified as part of the flooding response. The purpose of the validation is to ensure that adequate resources (personnel, equipment, materials) are available to implement the individual strategies to achieve the intended results. In its FE, the licensee stated that detailed instructions for the installation of the trigger-initiated LIP flood protection will be provided in SU-PROC-000-0-0P-ZZ-021, "Severe Weather Preparation”; 0-AP-37.01, "Abnormal Environmental Conditions"; or equivalent new procedure. To reduce installation time, the flood barriers will be pre-staged near locations requiring flood protection. Required equipment and personnel needs for flood barrier installations, and flood barrier installations will be described in the updates to the aforementioned procedures. In addition, the licensee stated in its FE that under a worst-case operations/maintenance minimum staffing scenario, the 24-hour LIP monitoring trigger in the revised procedures will initiate requests for additional personnel to support the flood barrier installation efforts. Approximately 12 hours would be available for the additional personnel to arrive on site within 12 hours of the LIP event reaching the site. This would allow an adequately staffed operations/maintenance crew capable of performing the LIP flood barrier installation in 6 hours. Finally, the licensee stated that once the revised procedures have been developed, the guidance described in NEI 12-06 will be applied to validate the LIP flood protection TSAs.

The NRC staff notes that the revised flood procedures proposed at the site have not yet been finalized, and as a result, were not reviewed in detail by the NRC staff. These procedures are SU-PROC-000-0-0P-ZZ-021, "Severe Weather Preparation;” 0-AP-37.01, "Abnormal Environmental Conditions;" and/or equivalent new procedure. However, the NRC staff notes that, if implemented as described, the proposed changes appear reasonable and are expected to provide well defined and unambiguous guidance. This conclusion was reached based on the site’s identification and protection against a forecast of consequential rainfall as defined in NEI white paper, "Warning Time for Maximum Precipitation Events" as endorsed by the NRC on

April 23, 2015 (ADAMS Accession No. ML15110A080), and NEI 16-05. The site has also developed anticipatory activities that incorporate triggers for when plant is cued to respond to the flood event, and inspection activities before and after the event. The licensee has also considered the TSAs at the site, and has committed to validation of these actions using the guidance described in NEI 12-06. Finally, the NRC staff also agrees that the actions proposed by the licensee would result in at least 6 hours of additional margin to implement the anticipatory flood protection actions under the worst staffing conditions, therefore demonstrating that the proposed actions are feasible and are expected to be accomplished prior to the LIP conditions arriving on-site.

3.1.3 Local Intense Precipitation Conclusion

The NRC staff has evaluated the information provided in the FE submittal related to the FLEX strategies, as evaluated against the reevaluated LIP hazard described in Section 3.1 of this staff assessment. The NRC staff finds that the proposed flood protection and procedures at Surry, if implemented as described, are expected to reasonably protect the site against the LIP hazard event. Furthermore, the NRC staff has determined that the strategies to maintain core cooling, containment integrity, and spent fuel pool cooling can be appropriately implemented upon installation of additional flood protection and the revision of plant procedures. The NRC staff made its determination based upon:

- The inclusion of action triggers based upon the 48, 24, and 12-hour warning time in the plant procedures for projected rainfalls of 4 inches or more;
- The action to establish plant conditions which protect SSCs that provide KSFs, such that an ELAP cannot be caused by the reevaluated LIP flood hazard; and
- The effectiveness of the licensee's planned actions, including regulatory commitments, for coping with a LIP event.

The NRC staff notes that the licensee has made several commitments that reference the completion of actions by the end of the second refueling outage for each unit. As part of the audit discussions, the licensee stated that the second refueling outage for Unit 1 is expected to occur fall of 2022, and the second refueling outage for Unit 2 is expected to occur spring 2023. Therefore, the NRC staff concludes that the licensee has demonstrated the capability, if implemented as described, to deploy strategies against postulated beyond-design-basis events for the LIP event, including associated effects and flood event duration. Furthermore, the licensee has provided a regulatory commitment to complete and maintain the strategies that would address a reevaluated LIP hazard at the site.

3.2 Dam Failure (Intake Canal)

For Surry, the NRC staff concluded in the FHRR staff assessment that there would be no site flooding associated with either a hydrologic upstream dam failure, or a failure of the embankment of the onsite settling pond. However, the NRC also concluded that a "sunny day" breach of the site intake canal was not bounded by the current licensing basis and warranted further analysis.

The licensee stated in its FE that the catastrophic "sunny day" breach of the intake canal earthen embankment results in a maximum stillwater elevation of **[[ ]]** MSL at the main site/power block near the southeast corner of Unit 2. The maximum flood levels are reached at approximately **[[ ]]** after the intake canal failure event initiation, and are about **[[ ]]** The analysis presented in the FHRR included several conservatisms, such as the initial breach is assumed to be **[[ ]]** the concrete liner is not credited; and the site storm drain system is assumed to be non-functional and thus not considered in the flooding analysis. In addition, other preventative maintenance procedures that ensure oversight and functionality of the intake canal, such as engineering procedure 0-STP-70.7, "Annual Intake Canal Liner Visual Inspection/Acceptance Test," and the fact that operations and security personnel are routinely in this area, would provide further assurance that intake canal leakage would be immediately reported to the MCR. (CEII)

As a result of these conservatisms, the licensee revised the analysis for the "sunny day" breach of the intake canal in the FE. First, the licensee stated that this failure event is not associated or concurrent with an initiating external event (i.e., an extreme flood, earthquake, Design Basis Event or BDB event). As a result of the hazard revision, the licensee determined that the new intake canal failure would result in **[[ ]]** Table 3.2-1 summarizes the results of the intake canal hazard evaluations at Surry.

In summary, the licensee's proposed site response relies on detection of the intake canal leak by plant personnel, lowering the intake canal by shutting down the circulating water pumps located at the intake structure in order to stop inflow. The existing inventory of water in the intake canal would then be lowered by using the condenser waterboxes located on the discharge side until the water level is at, or below site grade (26.5 ft. MSL). Additional details are described in the following sections.

Table 3.2-1 Intake Canal Hazard Evaluation at Surry

(CEII)

Current Design Basis Elevation (MSL)			**Hazard Elevation in FHRR (MSL)**			**Revised Hazard Elevation in FE (MSL)**		
Stillwater	Waves/Runup	Total Elev.	Stillwater	Waves/Runup	Total Elev.	Stillwater	Waves/Runup	Total Elev.
No Impact Identified			**[[**					**]]**

3.2.1 Revision to the Dam Failure (Intake Canal) Flood Hazard Analysis

Using a failure modes analysis, the licensee determined in the FE that a piping failure of the embankment was a more realistic "sunny day" breach of the intake canal. Dominion assumed the piping diameter in the embankment progressed from a diameter of **[[ ]]** Flowrates through the piping breach were modelled using a commercial software package for culvert analysis and design. Conservative parameter values were used for Manning's roughness coefficient "n" and the entrance coefficient based on guidance found in the Federal Highway Administration, Publication No. FHWA-HIF-12-026, "Hydraulic Design of Highway Culverts" dated April 2012. The inflow hydrographs from the intake canal through the embankment were generated by using progressively larger pipe diameters in the software, which led to larger flowrates. In its FE, the licensee assumed three different piping locations along the canal for estimating the maximum flood level. (CEII)

The inflow hydrographs were entered at three locations in the FLO-2D model. This model was previously reviewed and approved by the NRC staff in the FHRR staff assessment.

Subsequently, the licensee performed 12 simulations using the FLO-2D model. There were only minor differences in the maximum flood levels from using different piping locations and (CEII) piping durations. The maximum flood elevations ranged from **[[ ]]** MSL in the areas of interest. This compares to **[[ ]]** MSL for the sudden breach scenario described in the Surry FHRR. The licensee then stated that inundation arrival times were correlated to the breach durations. Breach duration and arrival times are summarized in Table 3.2.1-1.

Table 3.2.1-1 Inundation Arrival Times Associated with Breach Duration.

Breach Duration (Hours)	Inundation Arrival Times (Hours)
12	5
24	8
40	18
50	24

The NRC staff reviewed the assumptions, inputs, and methods used by the licensee in the revised FE analysis. The NRC staff agrees that assuming 3 different piping locations and subsequently performing 12 failure simulations is a representative sample that would adequately characterize and analyze a piping type failure in a concrete-lined canal. In addition, the NRC staff also agrees that a piping type failure is a more realistic representation of the embankment failure, in lieu of a sudden breach failure. This determination is made based on the inherent conservatisms included in the licensee's evaluation, and the availability of preventative maintenance procedures that ensure oversight and functionality of the intake canal.

Based on the information provided by the licensee, its own independent analysis, and verification of literature, the NRC staff agrees that the model revisions are acceptable. This determination is primarily based upon the adequacy of the methods and reasonable parameter values used, and the small differences in the results between the sudden breach scenario described in Surry's FHRR, which has been reviewed by the NRC staff, and the revised scenario described in the FE.

3.2.2 Site Response - Intake Canal Failure Event

After the model revision(s) described in Section 3.2.1 were performed, the licensee then evaluated the impact of a piping-type failure of the intake canal at the site. The complete details of the licensee's evaluation are described in Dominion (Zachry) Calculation, 13-143, Rev. 1, "Evaluation of Dam Failures for Surry Power Station." In summary, the licensee determined that that a minimum of 9 hours was available before flood waters from an intake canal failure exceeded the main site SSCs (i.e., the Turbine Building and Condensate Building).

The licensee stated that the 9-hour determination is conservative because it assumes that the site storm drainage system is nonfunctional, and that the 9-hour flooding timeline is initiated with a 1-inch diameter pipe leakage hole in the intake canal earthen embankment. The licensee further stated that the 1-inch diameter pipe leakage hole is conservative because it would take additional time for a hole of this size to form, and leakage indicators would have transpired prior to a leakage hole eroding to this magnitude. As a result of this information, the licensee concluded that the 9 hours available do not provide sufficient warning time at Surry for the installation of temporary flood protection barriers. However, the licensee stated that the available time is sufficient to implement revised procedural actions for mitigating flooding resulting from an intake canal embankment pipe type failure.

As part of the audit, the NRC staff asked the licensee what periodic maintenance and surveillance programs, if any, are routinely performed at the site to maintain the storm drainage system. In its response, the licensee stated that site procedure SU-PROCSU-ADM-MA-AA-113, "Yard Control," provides instructions to ensure that the outside yard areas (which includes drains, drain paths, grading, and BDB staging areas and haul paths) are maintained. The procedure specifically directs plant personnel to maintain drains and drain paths clear of blockage, and also directs personnel to follow systematic procedures in the event that a drain (or drain path) needs to be blocked, or is found to be impaired. This procedure would result in the plant personnel developing a condition report to correct the impairment. The NRC staff notes that a schematic of the storm drainage system at Surry can be found at site drawing 11448-FB-1A, "Yard Storm & Sanitary Sewer."

(CEII) The NRC staff also reviewed Calculation, 13-143, Rev. 1, "Evaluation of Dam Failures for Surry Power Station," and found that 9 hours duration was the most conservative time selection occurring at three doors, and the rest of the locations evaluated had additional time for each of the three breach scenarios evaluated. **[** **]]**. Other doors have an approximate range of 11 to 36 hours available before flooding from the corresponding modeled breach would reach the door thresholds. The NRC staff agrees that this information is useful and would better direct site personnel and efforts in a risk-informed decision-making event, should a similar event occur.

As a result of the above information, the NRC staff agrees that assuming the storm drainage system is nonfunctional is a conservative assumption, given that the licensee has systematic controls in place that would provide reasonable assurance that the storm drainage system would be functional, and therefore could be credited as part of the flood response. This more realistic assumption is expected to result in lower flood levels at the site. The NRC staff also agrees that assuming a 1-inch diameter hole at the beginning of the event is conservative because in reality, the intake canal has a concrete liner covering the embankment of the canal, which was not credited as part of the analysis. Finally, the staff also notes that deterioration of the 4.5-inch-thick concrete liner to the point of forming a hole of this magnitude is expected to take time, which in turn results in added margin to the analysis.

<u>Time Sensitive Actions (TSAs)</u>

Once Dominion determined that 9 hours of warning time were available at Surry, the licensee performed ETE-CME-2016-0005, Rev. 0, "Evaluation of Surry Circulating Water Intake Canal Earthen Embankment Internal Erosion Detection and Mitigation." This technical evaluation sought to validate the actions that need to be performed at the site against the available warning time, and describes the typical timeline for site personnel to detect and report the leak, and to implement the proceduralized leak mitigation actions. Licensee document ETE-CME-2016-0005 describes the response as divided in three response periods: flooding detection time (period of time available from where leak is detected until it is reported to the MCR), operator action time (period from MCR receiving report until plant operators have stopped the circulating water pumps), and flooding mitigation time (period from when the circulating water pumps are stopped, until the intake canal water is below site grade). The site response varies based on the mode of operation of the plant (outage vs non-outage) as follows:

Intake Canal Failure Response Timeline	
Scenario 1: Non-outage and 6 waterboxes	
Detection time	7 hours 58 minutes
Operator Action Time	40 minutes
Mitigation Time	22 minutes
Total Time	9 hours
Scenario 2: Dual Unit Outage and 3 waterboxes	
Detection time	7 hours 37 minutes
Operator Action Time	40 minutes
Mitigation Time	43 minutes
Total Time	9 hours
Source: Section 7.2.3.4 of Surry Focused Evaluation	

In summary, the licensee determined that even with minimum staff on site, sufficient leak detection time exists for associated site response actions to be completed prior to consequential flooding of the site. Specifically, there is sufficient time for notification, operator actions to verify leakage, and initiate lowering of the intake canal level by turning off the circulating water pumps until the canal level is below the grade level of 26.5 ft. MSL.

As part of its review, the NRC staff sought to verify that the proposed strategy at Surry could be implemented successfully in an organized pre-planned manner, that workers have been properly trained (or will be, as applicable), and that site personnel have demonstrated the ability to complete the requested tasks within the designated timeframe and within the expected environmental conditions. The staff also sought to identify what redundant, compensatory, or confirmatory measures are in place that would address the potential for incorrect execution of the proposed actions.

<u>Detection Time</u>

The NRC staff reviewed ETE-CME-2016-0005, Rev. 0 and found it reasonable to assume that plant personnel will successfully identify a leak in the focus area of the intake canal. The focus area of the piping breach is located at the west end of the intake canal, where intake canal water could impact the site the most. The NRC staff's determination is based on a review of the Surry analysis of foot traffic in the area, which is included in one of the FE references. Per Surry Operations log procedure 0-LOG-OS-001R, "Outside Logs," and the Management Expectations Document, two independent operators make rounds in the focus area twice in each 12-hour period. That is a minimum of eight operator rounds a day. In addition, the focus area of the intake canal is in the Protected Area of the plant, which is monitored 24-hours a day by security personnel. Fence patrols and security rounds provides further assurance that unusual conditions will be identified and reported.

The NRC staff determined that based on the above information, it is reasonable to conservatively assume that a plant worker will be near the focus area at least once every 3 hours, at a minimum.

In addition, the licensee stated in its FE that procedural training and compliance will be required to qualify applicable site workers (e.g., operations personnel, security officers, and general station personnel) to detect and report indications of leakage due to a failure of the intake canal earthen embankment. The NRC staff notes that the licensee provided a regulatory commitment in its FE to provide training to station personnel in order to understand and implement the appropriate response and actions. The regulatory commitments are expected to be implemented by the end of the second refueling outage for each unit (after NRC approval of the Surry FE). As part of the audit discussions, the licensee stated that the second refueling outage for Unit 1 is expected to occur fall of 2022, and the second refueling outage for Unit 2 is expected to occur spring 2023.

Based on the licensee having identified the proposed actions and training as a regulatory commitment, the NRC staff appropriately credited the proposed changes that Dominion has planned or implemented at the site as part of its review. The NRC staff expects that the licensee will address the regulatory commitments consistent with NEI 99-04, Revision 0.

Operator Action Time

The NRC staff then reviewed the process of plant personnel shutting down the circulating water pumps. For background purposes, the NRC staff notes that the circulating water pumps are part of the circulating water system, which provides cooling water for the main condensers and the service water systems of both units. Each unit requires 840,000 gallons per minute (gpm) of river water to supply condensing and service water needs. To provide operational flexibility, system reliability, and station economy, the water requirement for each unit is supplied by four 220,000-gpm pumps at 28 ft. total dynamic head when running at 220 revolutions per minute (rpm). Each circulating water pump is driven by a vertical, solid-shaft, 2000-horsepower, induction motor. These pumps then discharge to the intake canal that conveys the circulating water to the station area. During normal operation, the water level in the intake canal is approximately 28 ft. above the level in the seal pit at the discharge canal. This differential head supplies the service water to the site.

The Surry Final Safety Analysis Report (FSAR) Section 9.9.3 states that due to the potential for the intake canal siphoning back through the circulating water pump discharge lines, the circulating water pumps will be shut down prior to the hurricane reaching the site. The normal operation differential head (approximately 28 ft.) supplies the service water to parallel flow paths through the bearing cooling water heat exchangers, component cooling heat exchangers, and recirculation spray heat exchangers, which are also in parallel with the main condenser. The plant has been modified to break the siphon at elevation 23 ft., however, the hurricane analysis required an elevation of 28 ft. to ensure adequate service water flows with peak river surge. Therefore, the circulating water pumps will be shut down and the siphon broken after raising the canal level to at least 28 ft. As a result of the above information, Surry determined the need to shut off the circulating water pumps as part of the storm surge event described in the IA.

During normal full-power operation, one component cooling pump and one component cooling heat exchanger can accommodate the heat removal loads for each reactor unit. Operation of two pumps and two heat exchangers is the standard procedure during the removal of residual and sensible heat during unit cooldown, although one pump and one exchanger may be safely used under these conditions. The licensee stated that the Operations personnel can stop any or all circulating water pumps for a short period without having to close or throttle the waterboxes and then, restart any number as required to maintain level below site grade indefinitely until embankment repairs are completed.

The NRC staff notes that the pumps are restarted using site procedure 0-OP-48.1.1, "Starting Any Circulating Water Pump." In this procedure, the licensee stated that based on discussions with Operations personnel, there is no issue with respect to starting a stopped circulating water pump during this event. The NRC staff notes that the waterboxes refer to the condenser waterboxes available at Surry. There are four waterboxes per unit, but as part of the analysis the licensee only credited three waterboxes per unit. In summary, the more waterboxes are used, the faster the water can be drained from the intake canal.

The NRC staff understands that site procedure 0-AP-12.01, "Loss of Intake Canal Level" will be revised to incorporate a systematic shutdown of the circulating water pumps, and will also include the site response timeline actions and the corresponding available response times, which vary slightly based on the configuration of the plant. In addition, restarting of the circulating water pumps will also be done in a systematic, proceduralized, and controlled manner. However, because the licensee has not yet revised the procedure, the NRC staff did not perform a detailed review.

Finally, the NRC staff asked the licensee to clarify why it was reasonable to assume that the operator action times for intake canal failure response are essentially the same as the operator action times for an internal flooding event, given the potentially different environmental conditions. In its response, the licensee stated that a pipe-type failure under a sunny day scenario would not present the harsh adverse weather conditions like other scenarios such as hurricane winds. In addition, in both scenarios plant operators are trained to first report an unusual leak event to the MCR, which then sends another operator to the area to investigate and confirm the situation. This time critical action to confirm the potential leak is done in 40 minutes. The NRC staff agrees that based on this failure mechanism, environmental conditions are not expected to impede plant personnel completing the proposed actions.

Mitigation Time

As a result of its review, the NRC staff agrees that clear and unambiguous procedural triggers have been established and validated (if implemented as described), that site personnel will be properly trained to identify and report canal leaks, and that there is enough time margin available such that the site mitigation actions (22 minutes for scenario 1, and 43 minutes for Scenario 2 to shut down the circulating water pumps) are reasonably expected to be completed within the 9 hours available, such that the consequential flooding is avoided and SSCs that provide KSFs are protected.

Finally, the NRC staff notes that in its MSA the licensee evaluated a "sunny day" intake canal failure, which is a more conservative evaluation than a piping type failure, and the NRC staff concluded in the MSA staff assessment that the "intake canal failure [from a sunny day event] flood hazard would not impact the FLEX equipment storage, haul paths, or Phase 3 National Strategic Alliance for FLEX Emergency Response (SAFER) Response Center (NSRC) staging areas, nor would it significantly impact the FLEX mitigating strategies for the scenario in which one or both units is in Mode 5 or 6." This provides additional assurance that a more conservative scenario has been adequately addressed at the site, and that it is reasonable to believe that the site has additional capabilities than those being credited as part of the FE response.

3.2.3 Development of Revised Procedures

The revised procedural actions proposed by the licensee consist of leak detection/identification followed by proceduralized operator actions that lead to lowering the intake canal level. As a result, a revision to procedure 0-AP-12.01, "Loss of Intake Canal Level" or other new procedures, are planned to implement the intake canal failure site response strategy. In general, the procedures will direct personnel to complete the following actions/activities:

- Upon detection of an intake canal leak, operational staff in the MCR will be notified and send additional plant operators to conduct an investigation.

- If the investigation determines an intake canal leak is occurring, staff in the MCR will direct operational staff to lower the elevation of the water inside the intake canal to below site grade of 26.5 ft. MSL. This will be done in accordance to proposed revisions that will be incorporated in 0-AP-12.01.

Upon implementation of these changes, the licensee concluded that the planned site response to the intake canal failure will effectively avoid flood impact on the site SSCs, and therefore will prevent KSFs from being compromised.

3.2.4 Dam Failure (Intake Canal) Conclusion

The NRC staff has evaluated the information provided in the FE submittal related to the protection strategies, as evaluated against the revised dam failure (intake canal) hazard described in Section 3.2 of this staff assessment. The NRC staff finds that the proposed flood protection and procedures at Surry, if implemented as described, are expected to reasonably protect the site against the intake canal failure hazard event. Furthermore, the NRC staff has determined that the strategies to maintain core cooling, containment integrity, and spent fuel pool cooling can be appropriately implemented upon the revision of plant procedures and training of site personnel. The NRC staff made its determination based upon:

- The inclusion of a clear and unambiguous action triggers that are systematically proceduralized, and will be performed by trained staff;

- The action to establish plant conditions which protect SSCs that provide KSFs by relying on site grade and manual actions; and

- The effectiveness of the licensee's planned actions, including regulatory commitments, for coping with a dam failure (intake canal) event.

The NRC staff notes that the licensee has made several commitments that reference the completion of actions by the end of the second refueling outage for each unit. As part of the audit discussions, the licensee stated that the second refueling outage for Unit 1 is expected to occur fall of 2022, and the second refueling outage for Unit 2 is expected to occur spring 2023. Therefore, the NRC staff concludes that the licensee has demonstrated the capability, if implemented as described, to have effective flood protection against postulated beyond-design-basis events for the dam failure (intake canal) event, including associated effects and flood event duration. Furthermore, it is also reasonable (should the need arise) to assume that FLEX strategies are available at Surry, and provide a defense-in-depth feature for maintaining core cooling, containment integrity, and spent fuel pool cooling, as documented in the MSA staff assessment.

3.3 Storm Surge

The licensee reported that the reevaluated storm surge and river flooding combined event (CE) at the site is based on a deterministic analysis described in its FHRR. The reevaluated storm surge CE (hereafter referred to as storm surge) flood level is reported to be 24.2 ft. MSL stillwater on the west side of the plant and this flood level would not result in flooding of the main plant/power block which has a nominal site grade of 26.5 ft. MSL. The storm surge on the east side of the plant is reported to have a stillwater level of 24.2 ft. MSL, which would combine with a 14.6 ft. wave runup, resulting in a maximum flood level of 38.8 ft. MSL. This flood level would inundate and potentially damage the low-level intake structure resulting in drain-down of the circulating water intake canal, and loss of service water to the plant. However, the licensee also stated that the storm surge reevaluated flood hazard does not impact the on-site FLEX mitigating strategies (Phase 1, Phase 2 and Phase 3).

As a result of the above analysis, the licensee performed the IA evaluation consistent with Path 4 of NEI 16-05, whose purpose is to demonstrate effective flood mitigation which utilizes SSCs, mitigation equipment and manual actions that are used to maintain or restore KSFs.
The NRC staff notes that the objective of the Path 4 evaluation is to define the strategy for maintaining KSFs for the unbounded flood mechanism being evaluated, and assess its effectiveness by demonstrating that the flood mitigation features are reliable and that the overall site response is adequate. The NRC staff evaluated the adequacy of the flood mitigation features consistent with Appendix B of NEI 16-05, and evaluated the adequacy of the site response associated with installation and execution of the flood mitigation strategy consistent with Appendix C of NEI 16-05.

3.3.1 Probabilistic Hazard Evaluation of the Deterministic Storm Surge Analysis

The storm surge event results in an unbounded maximum reevaluated flood hazard stillwater elevation of 24.2 ft. MSL on the west side of the plant (at the main plant/power block); and 38.8 ft. MSL (24.2 ft. stillwater + 14.6 ft. waves/runup) on the east side of the plant (at the low-level intake structure). These storm surge results incorporated an antecedent water level estimate which combined the 10 percent exceedance high tide and historical sea-level rise (SLR) projected over 50 years. These quantities were estimates using data from the NOAA Sewells Point tide gauge (Station ID: 8638610). Additional details, including the NRC staff's review and conclusions associated with the deterministic storm surge analysis are described in the FHRR staff assessment.

Because the licensee did not revise the deterministic storm surge values previously evaluated, the NRC staff's review of the IA focused on the likelihood of the deterministic storm surge peak stillwater elevations and peak wave effects. The NRC staff used results from the U.S. Army Corps of Engineers (USACE) North Atlantic Coast Comprehensive Study[1] (NACCS) to estimate the likelihood of the deterministic storm surge peak stillwater elevation. The NACCS is used to estimate coastal storm hazards for the Virginia to Maine coastal region. The main goal of the NACCS study was to determine the magnitude and uncertainty of existing and future forcing for use in assessing coastal planning and engineering projects for flood-risk reduction and increased resiliency. Rigorous regional statistical analyses, storm climatology, and detailed high-fidelity numerical hydrodynamic modeling were conducted in order to quantify coastal storm wave, wind, and water level extremal statistics. The NACCS modeled water levels are referenced to MSL.

The NACCS storm surge and wind wave results were obtained from the USACE Coastal Hazards System (CHS).[2] Figure 3.3.1-1 of this report shows the location of the NACCS Save Point closest to the low-level intake structure at the east end of the plant. Stillwater levels were then obtained for ADCIRC Save Point 17451 and wind wave results were obtained for STWAVE Save Point 4400. The NRC staff notes that ADCIRC is a system of computer programs for solving time dependent, free surface circulation and transport problems in two and three dimensions. These programs utilize the finite element method in space allowing the use of highly flexible, unstructured grids. The NRC staff also notes that STWAVE is a steady-state, finite difference, spectral model based on the wave action balance equation whose purpose is to provide a model for nearshore wind-wave growth and propagation.

<u>Stillwater Elevation</u>

The NRC staff obtained the NACCS stillwater elevation at ADCIRC Save Point 17451 (as a function of annual exceedance probability (AEP)) by using the CHS for base conditions with 96 random tides. Subsequently, the NRC staff adjusted the water levels to account for SLR using the USACE Sea-Level Change Curve Calculator (SLCCC).[3] To do this, the NRC staff focused on Sewells Point tide gage location and relied on the SLCCC coupled with the NOAA 2017 Intermediate Global Sea-Level Rise Scenario[4]. The NRC staff found that a projected SLR of 2.4 ft. for the year 2060 was appropriate for consideration. The projected SLR at the Sewells Point gage was linearly added to the NACCS results. The SLR-adjusted NACCS stillwater elevations are shown on Figure 3.3.1-2 of this report.

The deterministic storm surge peak stillwater elevation of 24.2 ft. MSL is also plotted on Figure 3.3.1-2. As shown in the figure, at an AEP of 1E-3, the mean NACCS SLR-adjusted peak SWE is approximately 15.0 ft. MSL and the 98 percent confidence limit is approximately 18.8 ft. MSL. At an AEP of 1E-4, the mean NACCS SLR-adjusted peak stillwater elevation is approximately 17.8 ft. MSL and the 98 percent confidence limit is approximately 21.6 ft. MSL. Based on the

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[1] North Atlantic Coast Comprehensive Study—Coastal Storm Hazards from Virginia to Maine. Vicksburg, Mississippi. Nadal-Caraballo, N. C., Melby, J. A., Gonzalez, V. M., and Cox, A. T. U.S. Army Engineer Research and Development Center, Technical Report ERDC/CHL TR-15-5, 228 p

[2] Coastal Hazards System, U.S. Army Corps of Engineers, Army Engineer Research and Development Center, https://chs.erdc.dren.mil/default.aspx (accessed 02/04/2020)

[3] Sea-Level Change Curve Calculator (Version 2019.21), U.S. Army Corps of Engineers, http://corpsmapu.usace.army.mil/rccinfo/slc/slcc_calc.html, (accessed 02/04/2020).

[4] Global and Regional Sea Level Rise Scenarios for the United States, Technical Report NOS CO-OPS 083, National Oceanic and Atmospheric Administration, National Ocean Service, Center for Operational Oceanographic Products and Services, January 2017, https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

above, the NRC staff determined that it is reasonable to assume that the likelihood for the deterministic storm surge peak stillwater elevation is less than 1E-4 and less than 1E-3 with margin.

Wave Effects

The NACCS did not compile wave height AEP values; however, the NRC staff previously ran simulations producing water levels within the 1E-3 (18 ft. MSL) and 1E-4 (21 ft. MSL) water levels adjusted for SLR. The NRC staff determined that these storms all produced wave heights at the time of maximum water level between 8.8 ft. and 10.3 ft. Notably, the modeled peak storm surge stillwater elevation did not significantly influence the wave heights at the time of maximum water level, with 9–10 ft. wave heights reached at maximum stillwater elevation between 6 and 21 ft. MSL. The NRC staff notes that the wave height applied by the licensee (14.6 ft.) at the east side of the plant is more conservative than the range of 8.8 to 10.3 ft.

Based on the NACCS SLR adjusted stillwater elevation values and a 10 ft. wave height, NRC staff estimates a wave runup elevation of 33.7 ft. MSL for AEP 1E-3 (98 percent confidence) and 36.6 ft. MSL for AEP 1E-4 (98 percent confidence). This indicates that the likelihood for the maximum standing wave crest elevation of 38.8 ft. MSL at Surry is less than 1E-4 and less than 1E-3 with margin.

Conclusion on the Probabilistic Hazard Evaluation of the Deterministic Storm Surge Analysis

Based on the NACCS stillwater elevation results obtained from the CHS for a save point just offshore of the Surry intake structure, the deterministic storm surge peak stillwater elevation (24.2 ft MSL) is estimated to have an AEP less than 1E-4 and less than 1E-3 with margin. In addition, based on the NRC model simulations combined with the NACCS stillwater elevation results obtained from the CHS for a save point just offshore of the Surry intake structure, the deterministic storm surge maximum wave crest elevation (38.8 ft MSL) is estimated to have an AEP less than 1E-4 and less than 1E-3 with margin.

Therefore, the NRC staff concludes that the storm surge flood mechanism elevations used in the Surry flooding IA are reasonable, and considered to be in the “low likelihood” range for the purpose of performing the NTTF Recommendation 2.1 evaluations and is consistent with the guidance described in NEI 16-05, Revision 1.

3.3.2 Potential Site Impacts as a Result of a Storm Surge Event

The intake structure ay Surry, located on the east side of the plant, houses the circulating water pumps that provides service water to the site via gravity flow of the intake canal. For reference, Surry FSAR Section 9.9 describes the Service Water System as water from the James River used as cooling water for heat exchangers that remove heat from the component cooling water system, the bearing cooling water system, the recirculation spray system, charging pump service water subsystem, and other station applications such as air conditioning and chilled water. The service water system is designed as a Class I system.

The intake structure is located approximately 1.25 miles east of the main plant buildings (the power block) and is an eight-bay reinforced-concrete structure. Each bay houses one of the eight circulating water pumps for the two units. In its FHRR, the licensee stated that the emergency service water (ESW) pumping equipment (pumps, diesel-driven pump motors, fuel oil tanks, etc.) is housed in a reinforced concrete structure above the deck of the circulating water intake structure. The floor and walls of the emergency service water pump house (ESPH) are watertight. The sill of the ESPH door and air intake louver openings are located at elevation 21 ft. 2 in. MSL.

In the analysis presented in its FHRR, the licensee considered historical storm surge data, including region-specific hurricane climatology, to develop a conservative set of synthetic hurricane meteorological parameters that were factored into the storm surge analysis. During a short duration of time in the probable maximum hurricane (PMH), the stillwater elevation level is expected to be above elevation 21 ft. 2 in. MSL, leading to the possibility of surging water entering into the ESPH.

To limit a buildup of water in the ESPH, the licensee stated that the air intake louvers are equipped with exterior covers which, when installed, limit water ingress into the ESPH. The exterior covers on these louvers prevent surging water from overtopping the watertight wells, which were constructed inside the ESPH for additional flood protection. For both ESPH doors and the intake louver openings, the corresponding seal plates (flood gates) and exterior covers, respectively, are required to be installed whenever hurricane conditions exist, or are forecasted to exist, to preclude significant water ingress. Both the watertight wells and the seal plates provide protection up to 24 ft. MSL, which is comparable to the storm surge stillwater level of 24.2 ft. MSL at the east side. The licensee also stated that the door seal plates and louver opening covers are procedurally installed.

With the normal air intake louvers covered, air for operation of the diesel-driven emergency service water pumps would be provided through the motor-operated dampers located in the top of the ESPH structure. The licensee stated that the positioning of these dampers under the exhaust hood precludes any significant water entry into the ESPH from wave overtopping or runup on the structure. The elevation of the exhaust centerline is 36.5 ft. MSL. When comparing the top elevation of the exhaust centerline (36.5 ft. MSL) against the total water elevation (38.8 ft. MSL) expected at the east side, the licensee conservatively assumed that the diesel-driven ESW pumps would be inoperable.

In addition to the potential impacts at the intake structure, the storm surge may impact the intake canal embankment. The top of the intake canal embankment is 36.0 ft. MSL and at a location near the intake structure, the intake canal could be subjected to a 39.9 ft. MSL total water level with wave runup elevation (24.2 ft. MSL + 15.7 ft. wave runup). When comparing the top elevation of the intake canal embankment (36 ft. MSL) against the total water elevation (39.9 ft. MSL) expected at the site, the licensee conservatively assumed that the intake canal inventory would be lost. In its FHRR, the licensee provided additional information about the intake canal and stated that the normal water elevation at the power station end of the canal will vary between 26.0 ft. and 30.0 ft. A minimum freeboard of greater than 4 feet is maintained between the canal water surface and the berm at 36.0 ft. during hurricane flooding of the river, thus providing an additional flood mitigation feature. As a result, the maximum intake canal level expected is 32 ft. MSL. This freeboard is procedurally maintained and is adequate to contain surges within the canal.

Additional Information Regarding the Emergency Service Water System

In Section 9.9.1.3 of the Surry FSAR, the licensee stated that a PMH will result in reduced available service water flow due to the decreased driving head across the gravity flow service water system. The driving head will be reduced since the river level, to which the service water flow path discharges on the west side, will be higher due to storm surge. The revised design basis PMH analysis documents the adequacy of the service water system to maintain the units in a safe intermediate shutdown condition by removing decay heat concurrent with the loss of offsite power. The design basis PMH analysis requires that operating units be brought to intermediate shutdown prior to the hurricane reaching the site and subsequently maintaining the reactor coolant system (RCS) temperature below 350 degrees Fahrenheit (°F). Units at cold shutdown or in refueling would be maintained at either cold or intermediate shutdown with RCS temperature below 350°F. Refueling activities would be suspended prior to the arrival of the hurricane. In accordance with design basis criteria, a design basis loss of coolant accident (LOCA) is not considered during the PMH.

Conclusion on Potential Site Impacts

The licensee conservatively concluded in the IA that loss of the ESW pumps or loss of the intake canal inventory would result in a total loss of service water required for unit heat removal (e.g., reactor decay, spent fuel pool, and containment heat removal using the residual heat removal (RHR) and/or component cooling (CC) systems) once the intake canal level dropped below the storm surge stillwater level at the discharge canal (on the west side of the plant). Figure 3.3.2-1 shows the intake structure on the east side of the plant, as well as the 1.25-mile intake canal leading to the site.

3.3.3 Site Response – Effective Flood Protection

West Side of the Plant

In its IA, the licensee stated that the main site/power block area of the plant site has a nominal grade elevation of 26.5 ft. MSL and is located on the west side of the plant site, which is subjected to the reevaluated deterministic storm surge flood hazard maximum stillwater flood elevation of 24.2 ft. MSL. Wave effects are minimal on the west side of the plant. Therefore, the APM is greater than 2.3 ft. for SSCs in the main site/power block. The KSFs are maintained or restored by SSCs in the main site/power block except for KSFs requiring service water.

The NRC concludes that based on the information provided by the licensee in its IA, as confirmed by its own independent analysis, Surry has demonstrated effective flood protection for the west side of the plant, that has APM, is reliable, and does not rely on human actions given that the site grade is a passive flood protection feature. As a result, the flood response to the deterministic storm surge event is considered to be adequate, and provides reasonable assurance that key SSCs that provide KSFs (other than those that rely on service water) will continue to perform their intended function for the duration of the event. No further analysis of flood protection at the west side of the plant is warranted.

East Side of the Plant up to elevation 36.5 ft. MSL

As part of the 50.54(f) flooding submittals, Dominion stated that site procedure 0-AP-37.01, “Abnormal Weather Condition Preparation” is initiated at Surry when certain abnormal environmental conditions are expected at the site. As part of the audit, the NRC staff reviewed 0-AP-37.01, Revision 75, and found that this procedure is used for several abnormal events such as forest fires, or fires on property; flooding, wind, or heavy rain that would cause a loss of safety-related equipment, equipment necessary for safe shutdown, or equipment necessary for plant operation; tornadoes, and relevant to the reevaluated storm surge; and hurricane force winds expected in Surry County.

With regard to hurricanes, entry conditions into 0-AP-37.01 occur when hurricane force winds are expected in Surry County within 36 hours, or when Station Management considers hurricane a threat due to projected path. A summary of the information and/or actions described in 0-AP-37.01 are:

- The procedure provides plant personnel with several sources of data where severe weather information can be continually obtained and monitored. These sources are the National Weather Service located in Wakefield, VA (staffed continuously), the Dominion Weather Center, and/or the NOAA website.

- The procedure directs anticipatory actions, such as closing doors (including the two ESPH doors), putting flood protection barriers in place, and preparing equipment required for shutdown. In addition, the NRC staff confirmed that Attachment B of 0-AP-37.01 includes specific actions to be completed at the ESPH, such as performing GMP-031, “Emergency Service Water (ESW) Pump House Stop Log Installation and Removal.” This procedure directs the installation of the pump house door seal plates (stop logs) on the two flood protection doors, installation of the intake damper air louver covers, and providing a portable sump pump for the ESPH, among other actions.

- Notify Engineering of the forecasted event to assist Operations with the identification of BDB FLEX equipment available and evaluate the need to suspend critical maintenance activities.

- Initiate site procedure OP-ZZ-021, “Severe Weather Preparation,” which confirms that the ESW pump house doors are closed and checks that all manholes are returned to functional condition.

- Confirm the intake canal water elevation to be between 28 ft. and 30 ft., which ensures the CLB minimum freeboard of greater than 4 feet is maintained between the canal water surface and the berm elevation of 36.0 ft.

- Inform plant personnel to monitor storm tide. If the storm tide exceeds 8.0 ft. MSL, the differential driving head for service water flow through the component cooling heat exchangers is reduced. Compensatory actions will be required to ensure adequate decay heat removal remains available. The licensee stated that category two hurricanes and above are the most likely to produce storm tides greater than 8.0 ft MSL.

In addition, Dominion's corporate hurricane response plan CO-PROC-OOO-HRP-NUCLEAR, "Hurricane Response Plan (Nuclear)," provides a corporate-level assessment of station operational status and delineation of corporate responsibilities and support staff requirements. The plan provides for an assessment of pre-storm preparedness and implementation of associated contingency activities. The plan also establishes post-storm guidelines, and addresses emergency staffing in terms of management, supervision and support personnel. The plan is intended to provide general guidelines for management to prepare for and recover from a hurricane. The plan contains activity checklists developed to expedite preparations for impending severe weather, as well as post-storm response actions.

In summary, with both units operating prior to the hurricane, the units are to be shut down two hours before the hurricane reaches the site. Surry FSAR Section 9.9.1.3 describes that, relative to the CDB PMH, "…decay heat will be removed using the circulating water/service water system until a loss of power occurs after which the auxiliary feedwater system will be used. For analysis basis, this is assumed to be 2 hours after the plant has shut down (i.e., the loss of power occurs coincident with the arrival of hurricane winds on site)." With regards to the analysis presented in the IA, loss of power also occurs when hurricane winds arrive on site, and the service water system is assumed to be lost 4 hours after the beginning of the event due to flooding of the ESW pumps, which are not protected above elevation 36.5 ft. MSL, are inundated.

The NRC staff notes that this is a conservative assumption given that early hurricane winds (winds at t=0) may cause a loss of equipment at the site (as supported by operating experience at other facilities). In addition, because the EDG and emergency power distribution systems are flood protected by the site grade and are available to provide power for the KSFs when implementing procedure 0-AP-37.01 response, the licensee is not expected to be in an ELAP condition as was assumed under Order EA-12-049. During the audit, the NRC staff asked, and the licensee confirmed that the reevaluated storm surge event would not be expected to result in an ELAP condition at the site. This results in the high likelihood that additional installed SSCs, which are normally relied upon for plant shutdown are available for use, if needed.

The NRC concludes that based on the information provided by the licensee in its IA, as confirmed by its own independent analysis, Surry has demonstrated effective flood protection for the storm surge event (up to elevation 36.5 ft. MSL) and until the hurricane event arrives on site (t=0). This determination is based on the systematic and proceduralized anticipatory manual actions described in the IA, which lead to reactor shutdown upon forecasted conditions, and installation of flood barriers and covers which allow the ESPH to be flood protected up to the elevation of the exhaust centerline (36.5 ft. MSL).

In addition, the NRC staff agrees that the licensee has provided a clear organizational response that accounts for the anticipated environmental conditions and has time-margin to achieve the anticipatory actions.

3.3.4 Site Response – Effective Flood Mitigation from elevation 36.5 ft. MSL up to 38.8 ft. MSL

In general, the mitigation strategy at Surry consists on providing an alternate supply of water to the site in order to provide cooling to SSCs that provide KSFs and rely on the Service Water System. The proposed plan will require moving a BDB High Capacity pump(s) from the BDB Storage Building to the Discharge Canal suction location, and running discharge hoses into the

Turbine Building. In the IA, the licensee stated that three BDB High Capacity pumps are stored in the BDB Storage Building and are available to provide alternate service water, as needed. However, as part of the audit discussions, the licensee identified an error in the IA and clarified that only two BDB High Capacity pumps are stored in the BDB Storage Building, and the other pump is stored in the Emergency Response Building. However, all three pumps are still available to supply alternate service water, as needed. Figure 3.3.4-1 of this report shows the geographical location of the discharge canal, the Turbine Building, and the BDB storage building.

In its IA, the licensee stated that the mitigation strategies at Surry begin once the ESW is assumed to be lost, which is approximately 4 hours after the hurricane winds[5] arrive at the site and approximately 40 hours after actions directed by Surry procedure 0-AP-37.01, "Abnormal Environmental Conditions" have begun. In addition, because the reevaluated storm surge flood does not inundate the main site/power block area west of the plant site, the flood mitigation actions described below will be performed indoors, or outdoors in the main site/power block area of the plant after high winds sufficiently subside to less than 50 miles per hour (MPH). Hurricane winds are expected to subside to less than 50 MPH at around 12 hours after the beginning of the event. A more detailed summary of the timeline for the proposed mitigation strategy is described below.

<u>Time Period t= -36 hours until t=4 hours</u>

During this time period, the licensee initiates 0-AP-37.01, "Abnormal Environmental Conditions" which includes site preparation for high winds and heavy rain, and ensuring the intake canal level is between 28 - 30 ft. MSL. If both units are at power, the licensee will begin shutdown procedures at around t= -24 hours by moving one unit to mode 4 (hot shutdown - temperature between 200°F - 345°F). At approximately t= -12 hours, the licensee will begin shutdown procedures of the other unit at power by moving the unit to Mode 4. If both units are in Mode 5 (cold shutdown - temperature ≤ 200°F), the licensee will achieve 200°F - 345°F on both units.

If one unit is Mode 5 and one unit is between 200°F - 345°F, the licensee will direct plant personnel to heat up the unit in Mode 5 to 200°F - 345°F. The licensee stated that the units in Mode 5 will be heated up to Mode 4 in order to allow control of RCS temperature by RHR and AFW, if required. This prevents a possible mode change when service water flow to the component cooling heat exchangers is reduced by the loss of head (gravity flow) as a result of the high storm surge level on the discharge side.

At approximately t=-4 hours, the licensee will the direct personnel to stop all but one of the reactor coolant pumps on the unit(s) whose temperature is between 200°F - 345°F. If the storm surge is approaching or predicted to exceed 8 ft. MSL, then plant personnel will stabilize the RCS temperature by using the steam generator pressure operated relief valves (PORVs) and replenishing the water via the AFW (using the motor driven AFW pump); then the plant operators will secure the secondary plant; align component cooling and service water systems in order to minimize (not isolate) the loads/service water flow requirements; plant personnel will

[5] In its IA, the licensee stated that a Category 1 hurricane wind speed is between 74 and 95 MPH. The action timeline at Surry is conservatively based on t = 0 for when a 74 MPH Category 1 hurricane arrives in Surry County (at the intake structure).

then start all three ESW pumps (diesel driven); and finally stop the circulating water pumps located in the intake structure.

In summary, this period will allow the licensee to achieve 200°F - 345°F on both units (with a 2-hour margin), and maintain RCS temperature by using the steam generator PORVs and AFW. Hurricane winds arrive at the site at t=0.

Time Period t=4 hours to t=12 hours

When the ESW system is assumed to be lost at t=4 hours, the licensee stated that the proposed revision(s) to the 0-AP-37.01, "Abnormal Environmental Conditions," procedure will first direct plant personnel to request the Phase 3 FLEX low pressure/high capacity pumps from the NSRC. Additional details on the SAFER center are described in the safety evaluation issued by letter dated August 4, 2016. These pumps will be delivered to the site within 24 hours, or no later than 28 hours after the beginning of the event. At this point, the licensee will also systematically isolate affected equipment that relies on service water.

Time Period t=12 hours to t=14 hours

The licensee then stated that the planned revision(s) to 0-AP-37.01 will direct personnel at t=12 hours to initiate the alternate spent fuel pool (SFP) cooling in accordance with Surry Power Station Abnormal Procedure, 0-AP-22.02, "Malfunction of Spent Fuel Pit Systems," if needed, until sufficient service water and component cooling capacity is restored for SFP cooling.

In addition, during this time period the licensee will initiate deployment of the BDB High Capacity pump(s) part of the alternate service water supply in order to address the reduced service water and component cooling loads in accordance with FSG-1/2-FSG-12, "Alternate Containment Cooling." The deployment is expected to be completed within 2 hours.

Time Period t=14 hours to t=16 hours

During this period, site procedure 0-AP-37.01 will then direct personnel to complete the deployment of the BDB High Capacity pump(s) (revised 1/2-FSG-12), and initiate restoration of the reduced service water and component cooling loads (reduced at t=-4 hours). Each BDB High Capacity pump can provide 1,100 - 1,200 gpm of service water flow.

Approximately 2 hours later (at t=16), the licensee is expected to have completed the restoration of the reduced service water and component cooling loads using the BDB High Capacity pump(s), as needed. If necessary, the BDB AFW pump(s) operating in low head/high capacity mode available at the site can provide additional alternate service water flow of approximately 1,000 gpm per pump. If service water flow from the BDB High Capacity and AFW pumps is not sufficient to support these loads, then RHR, SFP cooling, service water to the MCR and ESGR chillers, and Containment cooling may be delayed until the SAFER center Low Pressure/High Capacity pumps are in service. Reactor decay heat may be continued to be removed using the steam generator PORVs/ AFW; SFP cooling may be accomplished with the emergency SFP makeup; and operation of the chillers and Containment cooling can be delayed until the Phase 3 FLEX Low Pressure/High Capacity pumps are delivered and deployed in approximately 1 day.

At this point of the event, the reduced service water and component cooling heat loads have been isolated for 12 hours. With regard to available water sources to use during this time period, the licensee stated that Dominion Calculation, MISC-11787, Rev. 0, Addendum A, "Evaluation of Secondary Heat Removal Requirements Following Extended Loss of AC Power (ELAP)" determined the AFW requirements for secondary heat removal with a 2-hour preemptive reactor shutdown to 345°F prior to an ELAP (i.e., prior to start of steam generator PORV/AFW reactor heat removal). This scenario is conservative with respect to the 0-AP-37.01 preemptive shutdown scenario which has a 4-hour preemptive reactor shutdown to 345°F and an ELAP scenario does not need to be assumed. Calculation, MISC-11787 found that emergency condensate storage tank (ECST) plus the emergency condensate makeup tank (ECMT) volume would provide approximately 18.7 hours of heat removal, with an additional approximately 7.6 hours of steam generator (SG) inventory available prior to SG dryout. This provides approximately 26.3 hours of available inventory. In addition, other on-site AFW sources provide for several days of decay heat removal capability following depletion of the ECST and ECMT.

With regard to the reactor coolant KSF, the licensee stated in the IA that FLEX analysis Dominion ETE-CPR-2012-0011, Rev. 10, "Beyond Design Basis - FLEX Strategy Basis Document and Final Integrated Plan" shows that RCS makeup is not required until more than 16 hours following loss of RCS injection (charging). In the IA scenario, the charging service water pumps and charging pumps are shutdown at t = 4 hours and can be restarted on or before t = 16 hours (2 hours after alternate service water is established) to restore RCS makeup (charging/letdown). Thus, RCS injection is suspended for approximately 12 hours.

Time Period t=28 hours and beyond

The Phase 3 FLEX Low Pressure/High Capacity pumps are expected to have arrived onsite. These pumps can provide approximately 7,800 gpm of service water flow, which exceeds the minimum service water flow for design basis component cooling heat exchanger heat load (which includes RHR, SFP coolers, containment air recirculation fans (CARFs) and control rod drive mechanism (CRDM) heat loads).

NRC Review of Timeline Analysis

The NRC reviewed the information provided by the licensee and agrees that the timeline analysis, if implemented as described, is adequate and meets the criteria described in NEI 16-05. This determination is based on the licensee demonstrating a well-defined event initiation criterion, well defined trigger actions to progressively complete the strategy that are unambiguous and provide clear guidance to plant personnel, a strategy focused on the TSAs, and manual actions that account for potential environmental conditions. The NRC staff notes that the licensee has not yet revised the 0-AP-37.01, "Abnormal Environmental Conditions" procedure, therefore the NRC staff did not perform a detailed review. In its IA, the licensee provided a regulatory commitment to develop and/or update applicable Station and Dominion Energy fleet procedures to provide appropriate guidance to station personnel, which includes 0-AP-37.01.

As a result of the licensee having identified the proposed actions and modifications as regulatory commitments, the NRC staff appropriately credited the proposed changes that Dominion has planned or implemented at the site as part of its review. The NRC staff expects that the licensee will address the regulatory commitments consistent with NEI 99-04, "Guidelines for Managing NRC Commitment Changes," Revision 0, dated July 1999 (ADAMS Accession No. ML003680088).

3.3.5 Validation of Time Sensitive Actions

To validate the feasibility of the proposed alternate service water strategy, the licensee stated in the IA that a similar FLEX strategy has already been validated in accordance with NEI 12-06, Revision 4, and Dominion ETE-CPR-2014-1010, Rev. 1, "Surry Power Station Beyond Design Basis FLEX Validation for Time Sensitive Actions (TSAs)." Specifically, the validated strategy is the FLEX AFW supply strategy deployment, which consists of moving BDB high capacity pump(s) from the BDB storage building and staging the pump(s) in the settling pond. Instead of using the settling pond, the proposed IA modification is to use the discharge canal and then running discharge hoses into the plant. The settling pond is adjacent to the discharge canal suction location on the northwest side of the plant.

The validation of the FLEX AFW strategy considered 2 hours for completion time, plus 2 additional hours for clearing potential debris from the haul paths. Additional details regarding the FLEX AFW supply strategy can be found at Dominion ETE-CPR-2012-0011, Rev. 10, "Beyond Design Basis - FLEX Strategy Basis Document and Final Integrated Plan."

The NRC staff reviewed this assumption and agrees that it is reasonable to assume equivalency of the proposed strategy in the IA, and the validated strategy for Order EA-12-049 given the similarities, and the geographic close proximity. Figure 3.3.4-2 of this report shows the geographical location of the settling pond and the discharge canal relative to the site. However, the NRC staff notes that the validation of the actions described above are for the actions corresponding to t=-2 hours until t=0, given that they are essentially the same as described in the CLB and the FIP. However, the site response from t=0 until t=4 when the ESW pumps are assumed to be lost due to flooding have not yet been validated. As a result, the licensee described in the IA a regulatory commitment to define plant protective measures, validate time sensitive actions, provide installation and response timelines (including warning time and period of site preparation), and confirm site strategy in accordance with NEI 12-06, NEI 16-05.

As a result of the licensee having identified the proposed actions to validate the TSAs as a regulatory commitment, the NRC staff appropriately credited the proposed changes that Dominion has planned or implemented at the site as part of its review. The NRC staff expects that the licensee will address the regulatory commitments consistent with NEI 99-04, "Guidelines for Managing NRC Commitment Changes," Revision 0, dated July 1999 (ADAMS Accession No. ML003680088).

3.3.6 Conclusion on the Storm Surge Hazard Event

The NRC staff has reviewed the Surry IA, supporting electronic files, and supporting calculation packages. The staff has found the licensee has adequately characterized the relevant flood parameters at the site, described the key SSCs impacted by the storm surge event, and has provided a proposed mitigation strategy that is reliable. The proposed mitigation strategy has effective flood protection with adequate APM, and also considered the reliability of the mitigation equipment and the TSAs required to successfully implement the strategy. This determination is supported by:

- The low probability of the event, as described in Section 3.3.1,
- The anticipatory actions that provide effective flood protection and the reactive actions that provide reliable flood mitigation, as described in Sections 3.3.3 and 3.3.4, and
- The licensee having identified the remaining actions to be completed, and the strategy to address the reevaluated storm surge event, through regulatory commitments included in the IA.

As a result, the NRC staff concludes that the flood response to the deterministic storm surge event is considered to be adequate, and provides reasonable assurance that key SSCs that provide KSFs will continue to perform their intended function for the duration of the event.

4.0 SENIOR MANAGEMENT REVIEW PANEL

In accordance with the March 2, 2020, Phase 2 decision-making memo, the staff communicated the results of the review with the recommendation that the storm surge flood mechanism at Surry be treated as a Group 1 hazard to the SMRP. The staff notes that only the storm surge flood-causing mechanism was in the scope of the SMRP, and evaluated as part of the IA. All other hazards were evaluated under the focused evaluation process described in NEI 16-05. The SMRP members provided input to the technical team related to the Path 4 storm surge flood hazard. The SMRP approved the staff's recommendation that the storm surge flood hazard should be classified as a Group 1 hazard, meaning that no further response or regulatory action is required.

5.0 AUDIT REPORT

The NRC staff previously issued a generic audit plan dated July 18, 2017 (ADAMS Accession No. ML17192A452), that described the NRC staff's intention to conduct audits related to IAs and issue an audit report that summarizes and documents the NRC's regulatory audit of the licensee's IA. The NRC staff activities have been limited to performing the reviews described above including the audit of calculation packages and procedures that supported the licensee's submittal. The staff determined that the information provided during the audit process served to verify statements that the licensee made in its FE/IA submittal. All references, drawings and/or calculation packages reviewed as part of the audit were found only to expand upon and clarify the information already provided on the docket, and so are not docketed or cited. Because this staff assessment appropriately summarizes the results of the documents that the staff audited, the NRC staff concludes that a separate audit report is not necessary, and that this document serves as the final audit report described in the July 18, 2017, letter.

6.0 CONCLUSION

The NRC staff has concluded that the licensee has adequately demonstrated that effective flood protection, if appropriately implemented, exists for the LIP and dam failure events. For the storm surge flood mechanism, the staff also agrees that the licensee has a reliable protection strategy for floods up to 36.5 ft. MSL, and an effective mitigation strategy for higher, less frequent floods up to 38.8 ft. MSL.

Based on the above, in accordance with Phase 2 of the process outlined in the 50.54(f) letter, the NRC staff concludes that additional regulatory actions associated with the storm surge reevaluated flood hazard, are not warranted. Finally, the NRC staff notes that the licensee has satisfactorily completed providing responses to the 50.54(f) activities associated with the reevaluated flood hazards.

Figure 3.3.1-1: NACCS Save Points Near to the Surry Intake Structure

Figure 3.3.1-2: NACCS Save Point 17451 Water Levels Adjusted for SLR (NOAA2017 Intermediate Scenario for 2060)

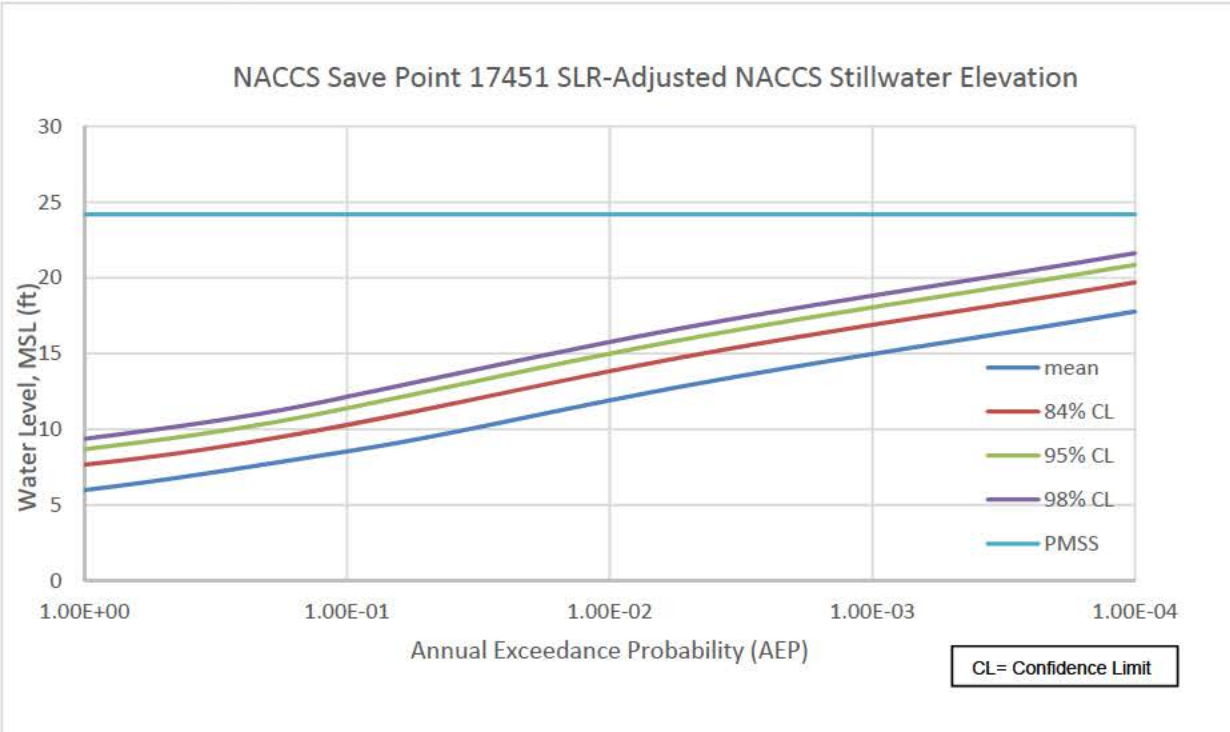
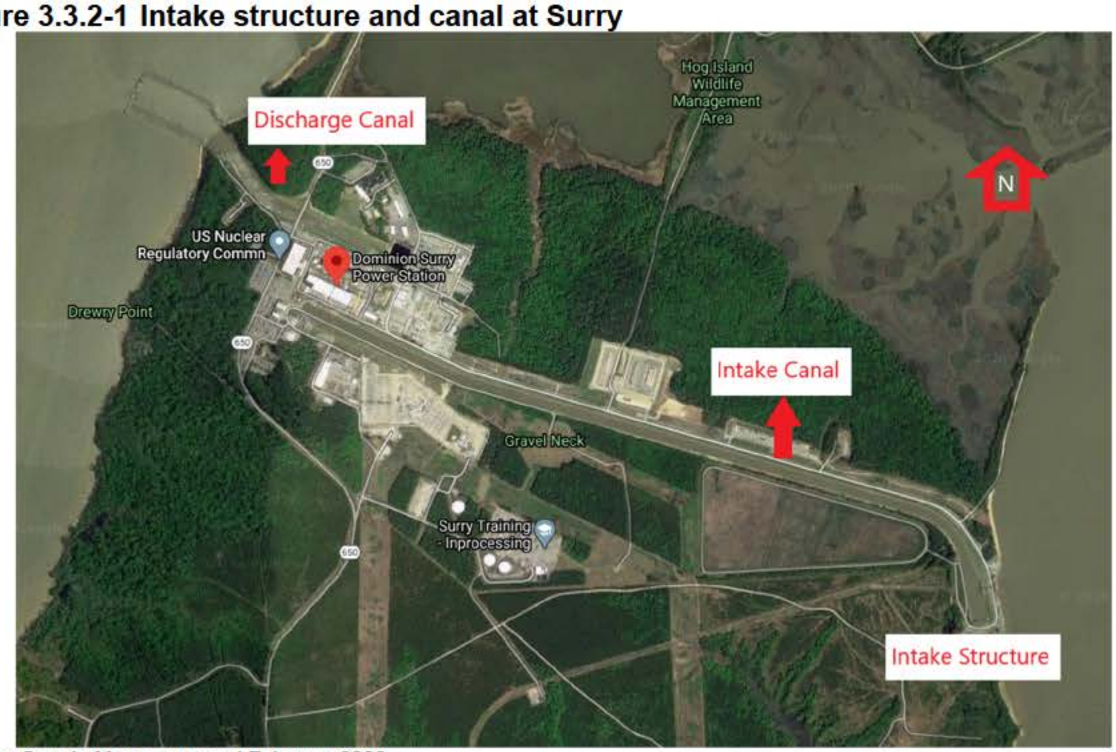


Figure 3.3.2-1 Intake structure and canal at Surry



Source: Google Maps accessed February 2020

Figure 3.3.4-1 BDB Storage Building and Discharge Canal at Surry

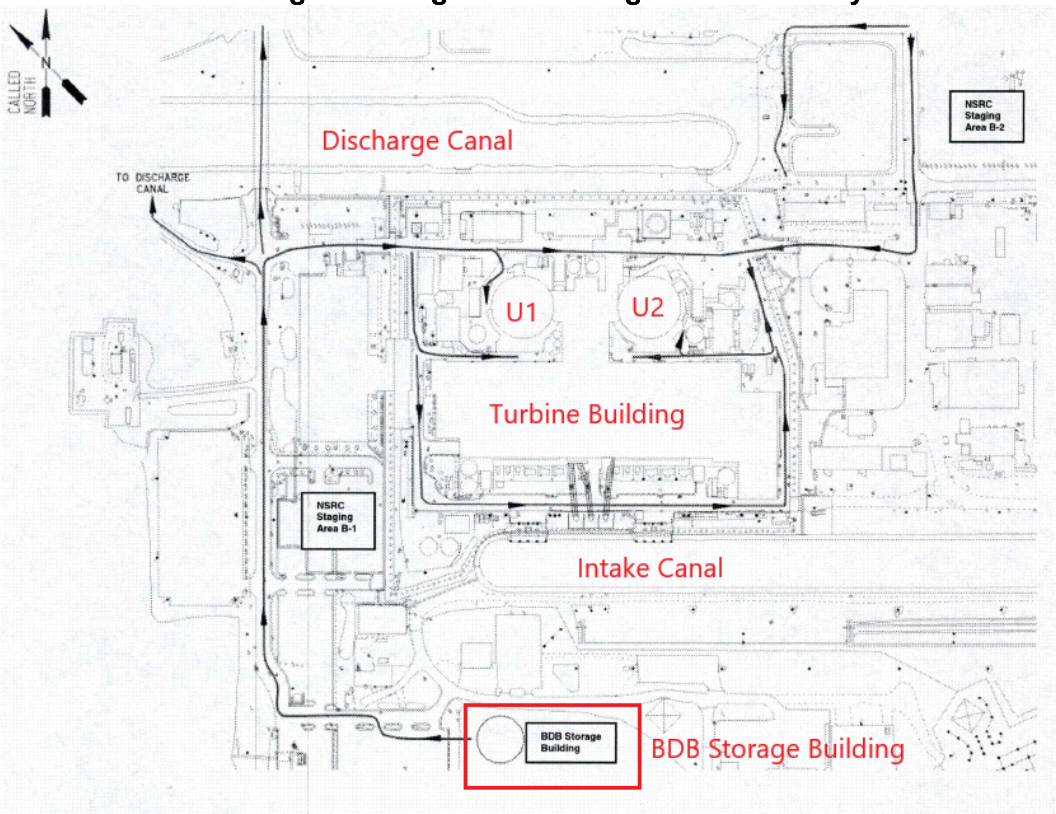
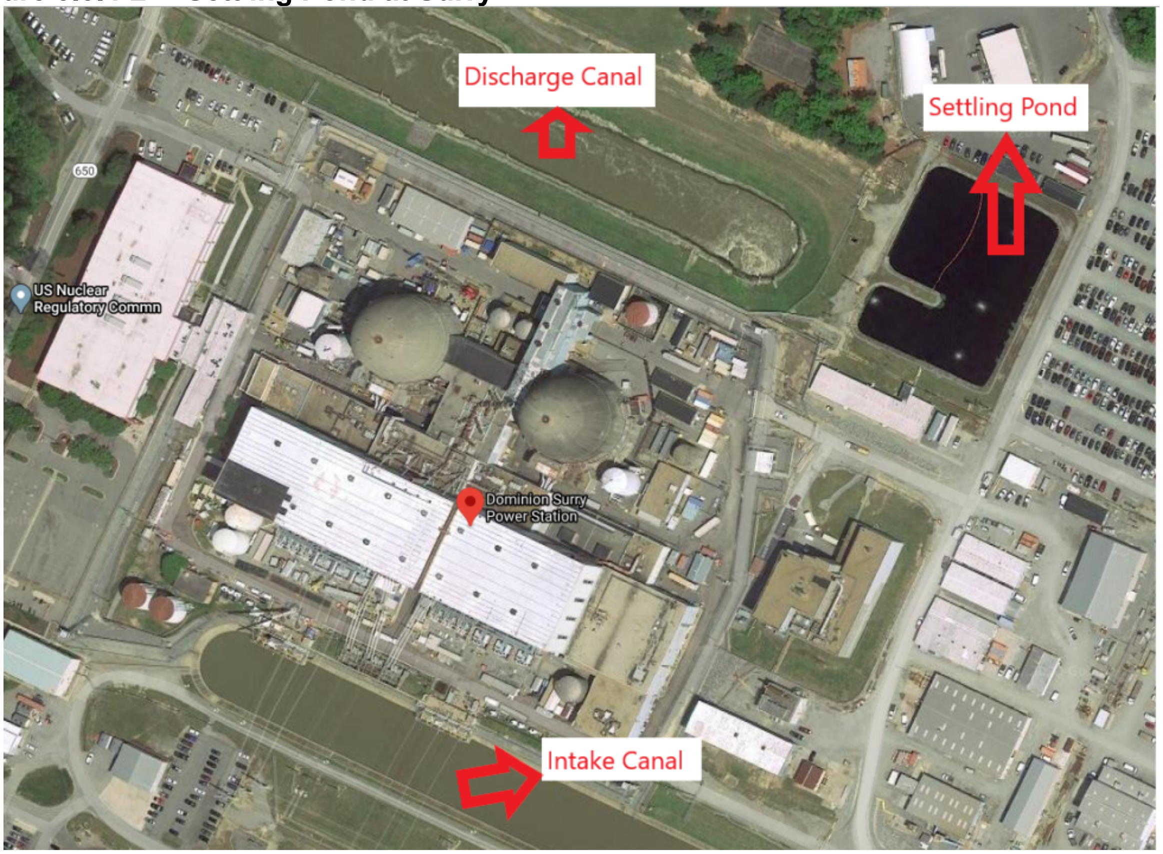


Figure 22: Haul Paths From BDB Storage Building and Staging Areas

Source: NRC Modified Figure taken from Surry Final Integrated Plan (ADAMS Accession No. ML16033A353)

Figure 3.3.4-2 Settling Pond at Surry



Source: Google Maps accessed March 2020