November 13, 2019

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

SUBJECT: NORTH ANNA POWER STATION, UNIT NOS. 1 AND 2 – ISSUANCE OF AMENDMENTS REGARDING INSTALLATION OF WATER HEADERS IN FLOOD PROTECTION DIKE (EPID L-2018-LLA-0485)

Dear Mr. Stoddard:

The U.S. Nuclear Regulatory Commission has issued the enclosed Amendment Nos. 283 and 266 to Renewed Facility Operating License Nos. NPF-4 and NPF-7 for the North Anna Power Station (North Anna), Unit Nos. 1 and 2, respectively. These amendments are in response to your application dated November 19, 2018, as supplemented by letter dated August 22, 2019.

The amendments approve installation of two non-safety-related water headers in a safety-related flood protection dike.

A copy of the related Safety Evaluation is also enclosed. A Notice of Issuance will be included in the Commission's biweekly *Federal Register* notice.

Sincerely,

G. Edward Miller, Project Manager
Special Projects and Process Branch
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-338 and 50-339

Enclosures:
1. Amendment No. 283 to NPF-4
2. Amendment No. 266 to NPF-7
3. Safety Evaluation

cc: Listserv

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

VIRGINIA ELECTRIC AND POWER COMPANY

DOCKET NO. 50-338

NORTH ANNA POWER STATION, UNIT NO. 1

AMENDMENT TO RENEWED FACILITY OPERATING LICENSE

Amendment No. 283
Renewed License No. NPF-4

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Virginia Electric and Power Company et al., (the licensee) dated November 19, 2018, as supplemented by letter dated August 22, 2019, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations as set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, by Amendment No. 283, Renewed Facility Operating License No. NPF-4, is hereby amended to accept the installation of the two water headers in the safety-related flood dike, as described in the application and supplement.

3. This license amendment is effective as of its date of issuance and shall be implemented within 60 days. Implementation of the amendment shall include updating the UFSAR in accordance with 10 CFR 50.71(e) to reflect this feature of the facility.

FOR THE NUCLEAR REGULATORY COMMISSION

Michael T. Markley

Michael T. Markley, Chief
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Operation

Attachment:
Changes to Renewed Facility
Operating License No. NPF-4
and Technical Specifications

Date of Issuance: November 13, 2019

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

VIRGINIA ELECTRIC AND POWER COMPANY

DOCKET NO. 50-339

NORTH ANNA POWER STATION, UNIT NO. 2

AMENDMENT TO RENEWED FACILITY OPERATING LICENSE

Amendment No. 266
Renewed License No. NPF-7

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Virginia Electric and Power Company et al., (the licensee) dated November 19, 2019, as supplemented by letters dated August 22, 2019, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations as set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, by Amendment No. 266, Renewed Facility Operating License No. NPF-7, is hereby amended to accept the installation of the two water headers in the safety-related flood dike, as described in the application and supplement.

3. This license amendment is effective as of its date of issuance and shall be implemented within 60 days. Implementation of the amendment shall include updating the UFSAR in accordance with 10 CFR 50.71(e) to reflect this feature of the facility.

FOR THE NUCLEAR REGULATORY COMMISSION

Michael T. Markley

Michael T. Markley, Chief
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Operation

Attachment:
Changes to Renewed Facility
Operating License No. NPF-7
and Technical Specifications

Date of Issuance: November 13, 2019

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO

AMENDMENT NO. 283 TO RENEWED FACILITY OPERATING LICENSE NO. NPF-4

AND

AMENDMENT NO. 266 TO RENEWED FACILITY OPERATING LICENSE NO. NPF-7

VIRGINIA ELECTRIC AND POWER COMPANY

NORTH ANNA POWER STATION, UNIT NOS. 1 AND 2

DOCKET NOS. 50-338 AND 50-339

1.0 INTRODUCTION

By application dated November 19, 2018 (Reference 1) and supplemented by letter dated August 22, 2019 (Reference 2), Dominion Energy Virginia, the licensee, requested the NRC staff review and approve a proposed amendment that would revise the North Anna Power Station (North Anna), Units 1 and 2 current licensing bases regarding a flood protection dike.

A safety-related flood protection dike located west of the Unit 2 turbine building (TB) and service building, which provides flood protection to those buildings, was modified by a design change in 2013. Specifically, a non-safety-related fire protection water header and a non-safety-related domestic water header was installed within the safety-related flood protection dike west of the Unit 2 TB.

The design change that implemented this change was evaluated by the licensee per the criteria specified in 10 CFR 50.59, "Changes, tests, and experiments," and was determined to not require prior NRC approval. During an NRC inspection (Reference 3), the 2013 modification was determined to have required prior NRC approval.

The license amendment request (LAR) seeks NRC approval for this design change and the associated Updated Final Safety Analysis Report (UFSAR) change that was implemented in 2013.

The NRC staff conducted an onsite audit at North Anna on July 15-17, 2019 in accordance with the audit plan (Reference 4). The purpose of this regulatory audit was to enhance the staff's technical understanding of the LAR as it related to the installed fire protection and domestic water lines and determine if it has negatively affected the safety-related flood protection dike on the North Anna site. The audit focus areas were to better understand related drawings, operator actions (human factors), and show the calculation methodologies, assumptions, and results that were applied by the licensee to reach conclusions in the proposed LAR. The audit is further described in Section 3.1 of this safety evaluation (SE).

A walkdown of the safety-related flood protection dike area was conducted during the visit to help the NRC staff better understand design changes implemented.

The supplement dated August 22, 2019, provided additional information and clarified the application but did not expand the scope of the application as originally noticed, and did not change the NRC staff's original proposed no significant hazards consideration determination as published in the Federal Register on March 26, 2019 (84 FR 11334).

2.0 REGULATORY EVALUATION

2.1 System Description

In Reference 1, Attachment 1, and Reference 2, the licensee describes the affected plant systems.

2.1.1 Flood Protection Dike

The safety-related flood protection dike is described in the North Anna Updated Final Safety Analysis Report (UFSAR), Section 3.8.6 (Reference 5). The earthen flood protection dike is located west of the Unit 2 TB and service building and provides flood protection to those buildings if Lake Anna reaches the Probable Maximum Flood (PMF) level. The flood protection dike was built to a crest elevation of approximately 271 feet, with a side slope that has a ratio of 2.5 horizontal to 1 vertical, except for a small section where the side slope is 2 horizontal to 1 vertical. The width of the flood protection dike is approximately 30 feet at the crest and 130 feet at its base. The length of the dike is approximately 350 feet.

In order to provide storm drainage to the area between the flood protection dike and Unit 2 TB, a drainpipe is installed within the flood protection dike. Technical Requirements Manual (TRM) Section 3.7.16, "Flood Protection" (Reference 6), requires closure of the valve in this drainpipe when the Lake Anna level exceeds elevation 252 feet. The normal level of Lake Anna is elevation 250 feet, reference UFSAR 3.4, "Water Level (Flood) Design Criteria". Valve closure ensures there is no leakage path through the flood protection dike during flood conditions that could challenge in-plant flood control measures.

The original analysis performed for construction of the dike determined the stability of the upstream and downstream slopes, including during the condition when water level on the outside of the flood protection dike has reached the PMF lake level (elevation 264.2 feet). The analysis found construction of the flood protection dike had adequate factors of safety.

2.1.2 Fire Protection System

The fire protection system is described in UFSAR Section 9.5.1 (Reference 6). The underground fire protection system piping (UFSAR Section 9.5.1.2.1) consists of a 12-inch diameter yard loop, with yard hydrants strategically placed around this loop. Branch lines from this loop serve the interior fire protection systems. The loop has a minimum ground cover of 5 feet for missile protection. The ground coverage depth was verified and documented in Reference 2, which confirmed the fire protection piping has approximately 6 to 7 feet of cover, and is located vertically below the dike crest, approximately 2 to 6 feet from the western edge.

The UFSAR Table 3.2-1, "Structures, Systems, and Components That Are Designed Seismic and Tornado Criteria," lists the Fire Protection System Yard Hydrant Piping System as designed such that it will not fail during a design tornado.

All of the fire protection systems piping and valves, including the supply lines from the fire pumps to the yard loop and the branch piping from the yard loop to the building walls, are designed to Seismic Category I requirements. The fire protection system drawing is Figure 9.5-1, "Fire Protection System Arrangement," of the USFAR.

The fire protection loop is fed by two, 100 percent (%) capacity fire pumps. The motor-driven fire pump takes suction from the North Anna Reservoir and the diesel-driven fire pump takes suction from the Service Water Reservoir. Each pump is designed to maintain 100 pounds per square inch gauge (psig) at its rated flow of 2500 gallon per minute (gpm) in the yard hydrant piping loop. The motor-driven, vertical-turbine fire pump is located in the fire pump house over the screenwall. The diesel-driven fire pump is located in the missile-protected Service Water Pump House (SWPH). The motor-driven fire pump is equipped with automatic control starting at 90 psi on decreasing line pressure. The diesel-driven fire pump is equipped with automatic control starting at 52 psi on decreasing line pressure at the elevation of the SWPH, which is equivalent to a loop pressure of 80 psig. Each pump delivers 2500 gpm at its designed discharge pressure (330 feet for motor-driven and 270 feet for diesel-driven), which varies because of the 66-foot elevation difference between the Service Water Reservoir and North Anna Reservoir. System pressure is normally maintained continuously between 105 and 115 psig by a pressure maintenance system consisting of a jockey pump, a hydro-pneumatic tank with an air compressor, and related controls and accessories

2.1.3 Domestic Water System

The domestic water system is described in UFSAR Section 9.2.3.1. The domestic water system consists of ground wells dug at various locations on site. Water is supplied from each well to its respective hydropneumatic tank, which acts as a surge volume and pressure source for the header. Each hydropneumatic tank discharges to a common header.

The common underground piping is regionally isolable to allow for isolation of any well house from the domestic water system without isolating water supply to the facilities in that area. The domestic water system supplies cold water for all domestic applications in the plant from toilets and sinks to drinking fountains and eyewash stations.

2.2 Proposed Change

The proposed LAR seeks NRC approval for a design change and associated UFSAR change that was implemented in 2013. In Reference 1, the licensee provided the following:

2.2.1 Background

In its submittal, the licensee stated:

> In 2013, a design change (DC) implemented at North Anna installed two non-safety-related water headers (fire protection and domestic water) within the safety-related flood protection dike west of the Unit 2 TB. The licensee's 10 CFR § 50.59 evaluation to support the DC concluded that prior NRC approval was not required based on an evaluation that the dike would not fail as a result of leakage or a pipe break. A subsequent inspection identified that a license amendment was required because the change resulted in a more than minimal increase in the likelihood of occurrence of a malfunction of the safety-related dike.

2.2.2 Current Requirements

With respect to current requirements, the licensee stated:

> There are no Technical Specification (TS) requirements associated with the flood protection dike, the fire protection system piping or the domestic water system. Operability/functionality requirements for both the flood protection dike and the fire protection system are controlled by the North Anna TRM. TRM Section 3.7.16, "Flood Protection," requires the valve located in the drainpipe routed through the flood protection dike be closed when the level of Lake Anna exceeds elevation 252 feet. In addition, when Lake Anna exceeds a level of 256 feet, the units are required to be in Mode 3 in 6 hours and Mode 5 in 36 hours.
>
> As described in UFSAR Section 2.4.10, "Flood Protection Requirements," (Reference 6) the design of Lake Anna limits the possibility of flooding the station because its maximum high-water level, including wave run-up, is below ground grade at the station site. A small area of below grade building exposure is protected by a dike to the west. The flood protection dike (with a crest at an approximate elevation of 271 feet) is designed to maintain a height and stability to ensure protection against maximum high-water level, including wave run-up of elevation 267.3 feet, to preclude impact to safety-related equipment.
>
> Fire Suppression Water Systems requirements are listed under TRM Section 7.1.1. "Loss of fire suppression water system features," and may require establishing a backup fire suppression water system via a cross-tie valve. TRM Section 7.1.8, "Fire Suppression System Impairments and Balance of Plant Fire Suppression," provides actions for the individual fire suppression systems and components rendered non-functional.

2.2.3 Reason for the Proposed Change to the Facility

With respect to the reason for the plant modification, the licensee states:

> A design change to facilitate the potential future addition of North Anna Unit 3 made changes to the Units 1 and 2 fire protection and domestic water systems. Underground fire protection and domestic water systems piping was abandoned west of Units 1 and 2, and new piping installed, including piping within the safety-related flood protection dike. NRC Inspection Report (Reference 3) identified a violation of 10 CFR § 50.59(c)(2) for failure to obtain a license amendment prior to implementing this design change because the change was determined to have increased the likelihood of a malfunction of the safety-related flood protection dike. As a result, this license amendment requests approval of the design change that installed two non-safety-related water headers within the safety-related flood protection dike west of the Unit 2 TB. Additionally, approval of the associated UFSAR change that describes the existing plant configuration with the non-safety-related water headers installed within the safety-related flood protection dike is requested.

2.3. Design Change to the Safety-Related Flood Protection Dike

As stated above, the safety-related flood protection dike, located west of the Unit 2 TB, was modified by the installation of two non-safety-related piping systems within the safety-related flood protection dike. The installed underground piping systems are the 12-inch diameter, ductile iron fire protection system piping, and the 2-inch diameter, high density polyethylene (HDPE) domestic water system piping. These pipes were routed within the western edge of the flood protection dike, along its entire length.

To facilitate the buried piping installation, a 10 foot wide, 4.5 feet deep trench on the western side of the flood protection dike was excavated. A smaller trench within the larger cutout was excavated for the pipes, and was 3 feet wide by 3 feet deep, extending the entire length of the dike. Following installation of the piping, the flood protection dike was restored to its original dimensions.

2.3.1 Fire Protection

The installed ductile iron fire protection system piping is cement-lined with an asphaltic exterior coating and has a polyethylene encasement wrap for corrosion protection. The fire protection piping runs parallel along the flood dike for the entire length, approximately 350 feet. The pressure rating of the piping is 350 psi and it is connected using restrained mechanical joints. The fire protection system piping was installed to Seismic Category I standards at an elevation of approximately 264 feet with at least 5 feet of soil above it for tornado missile and freeze protection. The fire protection system piping within the flood protection dike can be isolated by post indicator valves, which are accessible above the PMF elevation. The fire protection piping within the flood dike was hydrostatically tested at 235 psig, in accordance with applicable codes and standards as defined in the referenced design change package (DCP 07-016).

2.3.2 Domestic Water

The 2-inch domestic water system piping consists of butt or electrofusion welded, HDPE. The domestic water piping runs parallel along the flood dike for the entire length, approximately 350 feet. The piping and fittings consist of a standard dimension ratio (SOR) 11, and are rated for 160 psig at 73 °F. The elevation of the domestic water system piping varies from 4 to 6 feet below the top of the flood protection dike. The domestic water system piping can also be isolated by accessible valves above the PMF elevation. An in-service leak test was performed, estimated to be a pressure between 60 - 70 psig, for the domestic water piping in accordance with applicable codes and standards as defined in the referenced design change package (DCP 07-016).

2.4 Proposed UFSAR Revisions

As stated in Reference 1, the UFSAR change, which describes the modification to the safety-related flood protection dike, includes the following revisions:

- Section 3.11.3, Corrosion Prevention for Underground Piping, shows the addition of cement-lined ductile iron fire protection system piping. Previously, only cast iron material was used for fire protection system piping.
- Table 9.2-10, Domestic Water Supply Component Design Data, deletes abandoned #4 well and added #8 well.
- Section 9.5.1.1, Design Basis, no longer refers to the Site Construction Office Building North (SCOBN) Sprinkler System. The SCOBN building has been abandoned, and the underground fire protection supply piping to the SCOBN was abandoned with that modification.
- Section 9.5.1.2.1, Fire Protection Water Systems, removes the reference to the underground fire protection loop going around the area formerly for Unit 3. The underground fire protection system piping in this area was abandoned by the modification.
- Figure 9.5-1, Fire Protection System Arrangement, depicts the new routing of the underground fire protection system piping.

2.5 Applicable Regulatory Requirements and Guidance

The NRC staff identified the following regulatory requirements and guidance as applicable to the proposed amendment to revise the UFSAR.

2.5.1 Requirements:

As described in 10 CFR 50.92, "Issuance of amendment," paragraph (a), in determining whether an amendment to a license will be issued to the applicant, the Commission will be guided by the considerations which govern the issuance of initial licenses to the extent applicable and appropriate. If the amendment involves a significant hazards consideration, the Commission will give notice of its proposed action.

The following Atomic Energy Commission (AEC) Criteria are applicable to the amendment, reference North Anna UFSAR Chapter 3, "Design Criteria – Structures, Components, Equipment, and Systems."

Fire Protection, AEC Criterion 3

> Structures, systems, and components important to safety shall be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions. Noncombustible and heat-resistant materials shall be used wherever practical through the unit, particularly in locations such as the containment and control room. Fire detection and fighting systems of appropriate capacity and capability shall be provided and designed to minimize the adverse effects of fire on structures, systems, and components important to safety. Firefighting systems shall be designed to ensure that their rupture or inadvertent operation does not significantly impair the safety capability of these structures, systems, and components.

Environmental and Missile Design Bases, AEC Criterion 4

> Structures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including LOCAs [loss of coolant accident]. These structures, systems, and components shall be appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit.

2.5.2 Guidance:

NUREG 0800, Section 19.2, "Review of Risk Information Used to Support Permanent Plant-Specific Changes to the Licensing Basis; General Guidance," Initial – June 2007, (Reference 7).

3.0 TECHNICAL EVALUATION

3.1 NRC Site Audit

The NRC staff conducted a North Anna Power Station (NAPS) onsite audit on July 15-17, 2019, in accordance with the audit plan (Reference 4). The purpose of this regulatory audit was to enhance the NRC staff's technical understanding of the LAR as it related to the installed fire protection and domestic water lines and determine if the design changes have negatively affected the safety-related flood protection dike on the North Anna site. The audit focus areas were to better understand related drawings, operator actions (human factors), and to understand the calculation methodologies, assumptions, and results that were applied by the licensee to reach conclusions in the proposed LAR.

A walkdown of the safety-related flood protection dike area was conducted during the visit to help the NRC staff better understand design changes implemented.

During the audit period, fifteen questions were identified. Of those questions, ten questions were identified by the NRC staff for follow-up resolution, as described in the audit summary (Reference 8). In Reference 2 the licensee provided supplemental information to the NRC related to the audit questions.

The NRC staff did not perform an independent review of the calculations associated with the plant modifications performed related to the flood protection dike from 2013. During the audit process, the NRC staff discussed the pertinent assumptions, inputs and summary of calculation results to develop an understanding of the proposed changes and adequacy to conform to regulatory requirements.

3.2 NRC Staff Technical Review of Hydrology

3.2.1 Dike Slope Stability Modeling

The licensee used slope stability modeling to assess the performance of the modified flood protection dike system under different loading conditions. In general, the stability of earth embankments is assessed using the limit equilibrium method of potential sliding of soil mass. Several equilibrium methods may be used depending on how static and interslice forces of soil masses are modeled. Slope stability is evaluated by a factor of safety (FS) which is a ratio of shear strength of the soil and shear stress required to maintain the equilibrium. Dominion stated that the typical minimum acceptable FS values for the soil slope applicable to safety-related nuclear power facilities are a ratio of 1.5 for a normal long-term loading condition, and 1.0 to 1.2 for an infrequent loading condition (e.g., earthquake). The NRC staff confirmed these limiting FS values are acceptable for the slope stability of the flood protection dike as these values have been used for various reactor licensing applications.

For the dike slope stability analysis, the licensee used a combination of two numerical models: a seepage model (SEEP/W) to simulate pore water pressures in the dike and a slope model (SLOPE/W) to estimate stability factors for the dike. To simulate pore water pressures in the dike, Dominion assumed the initial groundwater level at the dike area is equal to the land surface elevation of 250.5 ft mean sea level (msl). The NRC staff finds this assumption is conservative as actual groundwater level at the site is lower than the land surface.

The licensee then applied a flood loading to estimate the change in pore pressure. Using the result of the seepage model simulations, the licensee established the relationship between pore water pressure and volumetric water content, as well as that of pore water pressure and hydraulic conductivity, at different design flood loadings. They then used the slope model to estimate the factor of safety for different dike cross-sections. The dike sections were discretized into finite element grids for use in a 2-dimentional slope model. The licensee used the hydraulic relations established from the seepage model as input to the slope model.

Using the slope model, the licensee simulated the stability of the dike at different dike conditions under the following three external loading conditions:

- Probable maximum flood (PMF) at Lake Anna
- A flood at half of the PMF coupled with the operating basis earthquake (OBE)
- 25-year flood with design basis earthquake (DBE)

The licensee simulated for upstream (west side) and downstream slopes with applicable loadings, separately. For instance, for the PMF condition, Dominion set the lake level of 264.2 ft msl on the upstream (west) of the dike and no water on the east side. There was no downstream flood loading included. The licensee considered four different cross sections applicable to before and after the dike modification. With combining these conditions, Dominion simulated a total of 24 runs for each scenario: three loading conditions, two dike slopes, and four equilibrium methods, namely, the Ordinary, Bishop's, Janbu's, and Morgenstern-Price methods. They used the soil property values obtained from field samples.

Using the seepage and slope models, the licensee analyzed the following four scenarios: regular dike cross-section, excavated cross-section, leak/break condition, and drainpipe abandonment. The staff reviewed each scenario as discussed below:

3.2.1.1 Scenario 1: Regular Dike Cross-section

This scenario is applicable to the dike section before and after the 2013 dike modification. To simulate this scenario, the licensee set the slope stability model with varying external loading conditions, as mentioned above. For instance, for the PMF flooding, the water level on the upstream (east side) slope reaches the Lake Anna PMF water level of 264.2 ft msl in one hour, and then remains there for 40 hours. Using the seepage and slope models, the licensee simulated a total of 24 runs for this scenario. The licensee demonstrated that the regular slope cross-section is considered to have enough stability as their computed FS values for all runs exceed the limiting FS value. The NRC staff confirmed during the site audit that the estimated factors of safety for these runs are greater than the acceptable limiting value including sufficient margin.

3.2.1.2 Scenario 2: Excavated Dike Cross-Section

This scenario is applicable during the dike modification, starting from the excavation of the dike and ending to the completion of backfilling. To install the fire protection system (FPS) and domestic water system (DWS) pipes, the licensee created a berm by excavating the upstream face of the dike, splitting the upstream slope into an upper segment of a 1:1 slope ratio and a lower segment of a 2.5:1 slope ratio. Basic runs for this scenario are the same as the above scenario. Additionally, the licensee simulated the following two cases separately to investigate different dike rupture (sliding) modes:

- Run the slope model with the upper segment slope (i.e., 1:1) only.
- Run the model with the two-segment slope, where the slope model was set to create a larger slip of soil mass across the two segments of the slope.

In total, the licensee performed 48 runs for this scenario. As a result, the licensee found that the excavated slope cross-section has enough stability for the postulated external loading conditions. The NRC staff confirmed during the site audit that the model used in this case is adequate and that the estimated factors of safety for this scenario are within the limiting value with sufficient margin.

3.2.1.3 Scenario 3: Pipe Leakage/Breakage

For this scenario, the licensee used a qualitative assessment to demonstrate that there would be no impact resulting from the dike modification. The licensee stated that a small leak from the DWS and/or FPS pipes would daylight (damp) on the upstream face of the dike at the pipe elevation, while a larger leak could form a visible seep on the face (Dominion, 2018). They also stated that, in either case, the computed stability of the dike would not be changed significantly from Scenario 1 for the following reasons:

- The seepage forces due to leakage are small.
- The weight of the dike materials remains essentially unchanged from Scenario 1 for which the slope modeling was set with the saturated soil weight throughout the dike.
- The slope failure was modeled for the 2-dimentional dike cross-section at the middle of the dike reach, resulting in conservative stability estimates compared to those resulting from a localized dike failure involving 3-dimensional effects.

The licensee stated that, without failing of the dike, the chance of complete breakage of the DWS or FPS piping is remote. Further, the licensee said the chance of such breakage occurring together with extreme flooding is extremely low. Nevertheless, the licensee addressed the following two potential leaking cases qualitatively:

- Two-inch pipe leakage: For a 2-inch DWS pipe leaking, the licensee asserted that even a complete breaking will not result in a flow rate that can wash out a significant portion of the dike. This may be true even if the leaking could occur for an extended period. It would require a considerable length of time to wash away the approximately 5 ft of soil materials above the pipe. The licensee stated that, during the time it would take to cause such pipe damage, the plant operator would have determined that the DWS had experienced a piping failure and stopped the flow in the DWS system to isolate the break location. Even if significant amount of soil material is washed away, the remaining portion of the dike itself has enough stability as was shown by the result of Scenario 2 runs. This is because the reduced weight at the top of the dike lessened the potential failure forces.

- Twelve-inch pipe failure: For failure of the 12-inch FPS pipe, the licensee indicated that considerable damage would be caused to the dike if the pipe failed and the failure went unchecked for an extended period. However, they asserted that this will not happen since there are a variety of methods employed to make the plant operator aware of the potential break or leak. The licensee said an initiation of action to isolate the break in the FPS piping would occur in a timely fashion.

In summary, the licensee stated that the failure of the dike system due to leaking from the pipes would be remote as the leaks would be detected in time to isolate the break of the pipes. The licensee also verified that in the event of a pipe break that washed out a portion of the dike, the remaining portion would maintain slope stability during various flooding events. During the site audit, the NRC staff conducted an inspection of the placement of surveillance instruments and systems. The NRC staff also reviewed the monitoring and inspection plans for the dike system. Based on the above, the NRC staff agrees with the licensee's conclusion of no impact of this scenario on the safety of the dike as any leak, either a small or large one, could be detected in a timely manner.

3.2.1.4 Scenario 4: Dike Cross-Section for Drainpipe Abandonment

Since the drainpipe beneath the dike will no longer serve its purpose when Unit 3 is built, it will be abandoned without compromising the integrity of the flood dike. To do so, the licensee proposed to put abutment soils on top of the existing dike toe to raise the fill height of the soil cover to more than 6 ft over the drainpipe. The licensee simulated the slope model with an assumption that the drainpipe suffers total corrosion so that the void left by the drainpipe could be a passageway for water flow during a severe flooding event.

The licensee first estimated the amount of water seeping into the void from the outside inundation using a modified seepage model where the model grids representing the drainpipe were set as a void which is considered as a boundary condition with zero water pressure. The licensee simulated the slope model for the dike cross-section with the abutment above the drainpipe. As a result, they showed the computed factors of safety are greater than the limiting value required for the safety-related embankment.

Moreover, the licensee assured that the actual water seeping into the void would be small compared to the void volume within the drainpipe so that the rupture (or washout) of the dike due to the seepage into the drainpipe would not occur. During the site audit, the NRC staff reviewed the modeling for this scenario as well as the calculation of potential seepage into the void of the drainpipe. As a result, the NRC staff finds the conclusion that the stability of the dike is not affected by the potential seepage through the abandoned drainpipe.

3.2.1.5 Other Factors Affecting Dike Slope Stability

Additionally, the NRC staff reviewed the following three conditions that could potentially affect the stability of the flood protection dike.

Wind Wave Runup Effects:

Using the slope model, the licensee analyzed stability of the flood protection dike with the Lake Anna PMF level as an external loading. The UFSAR for the North Anna Units 1 and 2 indicates that runup during the PMF event at the plant site along the Lake Anna coast is estimated to be 3.1 ft. The runup was estimated based on a 2-year wind wave along the longest wave fetch across the lake. However, the LAR did not address the effects of the runup on the slope stability. The runup would act as a repeated loading to the dike during the flooding event because the period of wind-induced wave is much shorter than that of flood inundation at the site (i.e., a few seconds for runup versus several hours for PMF). The NRC staff questioned this issue during the site audit.

The NRC staff requested that the licensee discuss the effects of an increased flood level due to runup on the dike slope stability analysis, or to justify why runup is not applicable to the slope modeling. The licensee provided the following in its supplement:

> As discussed in the original slope stability calculation, CE-0638, the top elevation of the dike (271') was chosen to provide adequate freeboard above the PMF water elevation plus the wave runup associated with the 2-year windspeed. However, the wave run-up was not considered critical with respect to the slope stability analysis and therefore was not considered. The excerpt from the UFSAR, Section 2.A.2.7, indicates that the intake structure for NAPS Units 3 and 4 is protected by a point of land, making wind effects non-critical. As noted on the site drawings, the flood dike is actually located behind the Unit 3 and 4 intake structure/screen wall (i.e. farther back from the lake), which would logically render wind effects moot.

During the walkdown conducted as part of the site audit, the NRC staff confirmed that the elevation of the backup dike south of the Units 3 and 4 intakes is high enough above the estimated lake PMF level to prevent overtopping of the PMF and high enough to interrupt the propagation of runup from the lake to the basin bounded by the flood protection dike. The NRC staff also noted that the runup created within the basin behind the Units 3 and 4 Intake would be insignificant as the fetch length for the basin is small (less than 1000 ft). Therefore, the NRC staff finds that PMF-induced wave runup is not applicable to the stability analysis for the flood protection dike.

Stability Analysis for Steep Slope:

The typical dike section analyzed in the slope modeling is 2.5 horizontal versus 1 vertical (2.5:1) as most of the dike reach has this slope. However, the licensee reported there is a portion of the dike that has a 2:1 slope. At the site audit, the staff questioned whether the licensee considered the steep slope in the slope modeling. In response, the licensee clarified that the steep slope appears only on the southern-end, downstream side of the dike, with an approximate length of 50 ft. They pointed that the slope stability for the 2:1 dike section will be equivalent to that of Scenario 2 for which the excavation section has a 2:1 slope on the south side. The licensee demonstrated the excavation section is safe even with flooding and seismic loadings. Correspondingly, the NRC staff concludes that the steep slope also has enough stability during design basis flooding events.

Additional, Uncredited, Slope Protections by Ground Cover:

Although not credited in the modeling, during the site audit, the NRC staff noted that the licensee's specifications state the seeding shall confirm to the codes and standards provided by "Virginia Erosion and Sediment Control Handbook," (Reference 9). The NRC staff noted that the handbook provides specific guidelines on top soil, fertilizers, seeds, and mulches. These include:

- The topsoil shall be distributed at a minimum depth of 4 inches after firming the seeding surface.
- Seeded areas shall be maintained by watering, cutting, and reseeding as necessary to provide a good stand of grass.

From the site walkdown, the NRC staff confirmed that the lawn covering the dike top and slopes are in a good condition. The NRC staff noted the surface lawn, while not credited in the licensee's slope modeling, would serve to enhance the slope stability by protecting the dike from natural and rainfall-induced erosion.

3.2.2 Sunny Day (Piping) Failure of Dike

In general, earth embankment (or dike) could be breached by different failure modes, including overtopping, seismic, and piping failures. The licensee reported the estimated PMF level at Lake Anna is 264.2 ft msl. Because the maximum flood level is lower than the top elevation of the flood protection dike (271 ft msl), there is no potential for an overtopping failure of the dike. The licensee also analyzed the slope stability of the flood protection dike using a numerical slope stability model at various flooding and seismic loading conditions. Therefore, the soil material for the dike has enough stability during severe flooding and seismic events. Therefore, there is no apparent potential for seismic failure of the dike.

In general, piping failure could occur by internal erosion (i.e., seepage) of the embankment or its foundation. It can happen with or without external flooding (such as a "sunny-day" failure). Flood loading could exacerbate internal pressure and seepage, leading to a piping failure of a dike.

For the flood protection dike, piping failure itself is not plausible because the dike is in dry condition most of the time. Even with a severe flooding, the chance of developing a complete piping line through the dike during a flooding event is remote as the embankment soil has low permeability. However, the likelihood of failure of the dike could increase when a buried pipe leaks, either in a small or large fashion. The NRC staff postulated that the water, due to a small undetected leak from the buried pipes, could move down and accumulate around the drainpipe area to make the soil in a wet condition in advance of flooding. This condition could create seepage or subsidence of the dike during a flooding event, leading to a dike failure. Because the timing of the leakage and the timing of the flooding could be different, this dike failure scenario is considered as an independent event and addressed in Section 3.2.3 of this SE.

During the site audit, the NRC staff questioned this type of piping failure. In its supplement dated August 22, 2019, the licensee stated that this event was excluded from the analysis because the FPS pipe leakage could be detected in multiple ways, including the following:

- Dampening on the western face of dike due to homogeneity of the soil.
- The slope of the drainage pipe falls to the west (confirmed by walkdown, and from interpretation of construction drawings), causing water around the pipe to drain around the exit line of the pipe.
- This event would require a large amount of water to leak. This much water leakage, over time, would be detected by FPS tank cycling.

Based on the above, the NRC staff concludes that failure of the dike due to pipe leaks or piping around the drainpipe is not plausible. In addition, during the walkdown the NRC staff identified many additional safety features, including: a berm with concrete wall and gravel pavement on the toe of the dike, concrete cover on the top of the dike, gravel surface on the downstream of the dike, and pumps to discharge water from the West Basin to the local drain system south. These features would add to the stability of the dike slope.

3.2.3 Risk Analysis

3.2.3.1 Dike Failure Assumptions

In addition to the dike slope stability analysis, the licensee performed a probabilistic risk assessment (PRA) to characterize the impacts of postulated pipe failures on the reliability of the flood protection dike. The licensee calculated the annual exceedance probability of the occurrence of a combined rainfall-induced flood and pipe failure event using the following assumptions:

- A double-ended break in the 2-inch domestic water system piping would not result in a failure of the dike to provide flood protection.
- A large break in the 12-inch fire protection system piping would be identified and isolated immediately. There is no external flood consequence if the pipe ruptures while storm runoff conditions with high lake levels are not present.
- The section of external flood protection dike of concern is approximately 350 feet long and dike failure could occur anywhere within the dike reach.
- The flood protection dike would fail should a fire protection system pipe failure (rupture) occur within a 7-day rainfall event since the pipe failure (rupture) will not be detected because of standing water near the break.

- The PRA considers a 1000-year rainfall of 15 inches in less than 72 hours as a "significant rainfall event" instead of a probable maximum precipitation (PMP) event.
- For the purposes of this PRA evaluation, the frequency (i.e., 0.001 per year) of a "significant rainfall event" is considered without using the actual value and duration of the significant rainfall event. It is assumed that if less than this amount of precipitation occurs, then there will be no apparent external flooding consequence in the event of a fire protection system pipe rupture. This assumption has conservative bias.

The licensee stated that the last two assumptions above provide a conservative bias in estimating the annual exceedance probability of the dike failure. The NRC staff finds that the third assumption results in a conservative probability estimate as the chance of a dike failure occurring away from the center of the dike reach would be low due to the 3-dimensional effects from buttressing of the dike ends by other crossing levees. Using the probability of a 1-in-1000-year rainfall is also conservative as its return period is smaller than that of the PMP. The rainfall estimate of 15-inches would be decreased if the areal rainfall for the entire watershed basin is considered (i.e., applying an aerial reduction factor).

The licensee clarified that the 7-day rainfall is based on the basin-wide PMP estimate provided in the UFSAR where the basin PMF was estimated using the following 7-day PMP scenarios in order:

- a combination of 40% of 2-day PMP,
- 3-day no rain, and
- 2-day PMP series.

Based on the above, the licensee performed a dimensional analysis reliability calculation to determine the likelihood of failure of the flood protection dike due to a 12-inch pipe rupture during a "significant rainfall event." The licensee stated that the use of a 1000-year rainfall event instead of PMP is appropriate because the annual exceedance probability of PMP is very low since PMF conditions have never been recorded at the North Anna site.

3.2.3.2 One-in-1000-year Rainfall

The licensee used a 1-in-1000-year rainfall for estimating the probability of dike failure in the PRA. Although this rainfall event is less conservative in terms of the magnitude and frequency of rainfall compared to a PMP, the NRC staff determined this approach is acceptable as it produces a conservative dike failure probability.

The licensee obtained a 1000-year rainfall value of 15 inches from the National Oceanic and Atmospheric Administration (NOAA) ATLAS 14 (Reference 10). This rainfall estimate was based on point precipitation frequency estimates at Louisa City, Virginia, located approximately 10 miles south from the NAPS plant site. The NRC staff performed a confirmatory calculation of the rainfall using the ATLAS 14 at the center of the watershed for the Lake Anna basin. The NRC staff obtained a 1000-year rainfall depth of 15.1 inches for the 3-day duration. As the NRC staff's value is nearly identical to the licensee's value, the NRC staff finds the Dominion's 1000-year rainfall estimate is acceptable.

3.2.3.3 Generic Water Pipe Failure Rate

The licensee used a generic rate of 0.14 failures per mile-year for the 12-inch ductile iron fire protection pipe. Dominion cited the NRC Inspection Report 05000338/2017007 and 05000339/2017007 as the source for the pipe failure rate. The inspection report mentions the generic failure rate for ductile iron pipe to be from 0.049 to 0.14 failures per mile-year based on the two reports by the Water Research Foundation from the University of Texas at Arlington (Reference 11) and Folkman (2012) published by Utah State University (Reference 12). NRC inspection report noted that these reports considered only significant pipe failures excluding small leakages.

In addition, the NRC staff found the following reported generic pipe failure rates from multiple literatures.

- Folkman, in 2012, reported 0.049 failures per mile-year for ductile iron pipe.
- The NRC staff found the Folkman report was updated with 0.0555 failures per mile-year for ductile iron pipe. This updated information is based on a large data set collected from approximately 2 million miles of drinking water supply main pipes throughout the contiguous United States.
- The Water Research Foundation also reported 0.14 failures per mile-year for ductile iron pipes over 24 inches in diameter. This failure rate is based on the data collected from 21 U. S. water utilities.
- The foundation also reported 0.085 failures per mile-year for ductile iron pipes based on the United Kingdom Water Industry Research (UKWIR) national failure database.

The additional values support the conclusion that the licensee-selected pipe failure rate is conservative. The Folkman report further stated that corrosion is a major cause of water main breaks, and that the break rate of newer and thinner-wall ductile iron pipe in highly corrosive soils is 10 times more likely than those in low corrosive soils. The Folkman report also provided a corrosive soil map within the contiguous U.S. The map indicates the soil at the plant area would be classified as "moderate" to "high" corrosive.

To prevent the corrosion of the pipe, the licensee installed the 12-inch ductile iron pipe on cement-lined bed with asphaltic exterior coating. The pipe also has a polyethylene encasement wrap for corrosion protection. The corrosion protection afforded by the internal and external pipe coatings further justify that the generic pipe failure rate chosen by the licensee is conservative when compared to the generic failure rates for water mains, which includes failures of uncoated pipes.

The NRC staff also considered the following additional factors in assessing the failure rate of 12-inch FPS piping:

- The Folkman report indicated the average pressure of water supply mains used in his report is 69 pounds per square inch (psi) with the maximum of 119 psi. The fire protection pipe will maintain a pressure of 110 psi, which is somewhat higher but still within the range for the Folkman data. Therefore, the use of a higher pipe failure rate by the licensee is acceptable.
- The flood protection dike is Seismic Category I structure and the fire protection pipe is lying on a 6-inch thick gravel bed. Therefore, rupture of the fire protection pipe would be less likely compared to that of water mains.

- The rate of pipe failure is higher during the winter season: however, the fire protection pipe at the site was buried by more than 5 ft soils, making the chance of pipe failure due to freezing low.

Based on the above, the NRC staff determined the licensee-selected pipe failure rate of 0.14 times per mile-year is acceptable to use in estimating the dike failure probability as that value is conservative.

3.2.4 Dike Failure Probability

The FPS pipe within the dike extends approximately 350 feet long. Considering that the size of the Lake Anna watershed basin is small (i.e., 343 square miles), the NRC staff finds the 7-day rainfall duration acceptable. The licensee calculated the probability that this pipe system would fail during the 7-day flooding duration. Using the generic pipe failure frequency of 0.14 failure per mile-year, the licensee calculated the annual frequency of pipe failure as:

$$\frac{0.14\,failures}{mile*year} * \frac{1\,mile}{5280\,feet} * \frac{350\,ft}{1} = 9.28E-3\;per\;year$$

Assuming the pipe failure and the dike failure occur simultaneously but independently, the licensee estimated the combined dike and pipe failure frequency by multiplying the frequencies of the two events with the 7-day duration as:

$$(9.28E-3\;per\;year) * (1.0E-3\;per\;year) * \left(\frac{7days}{365.25\;days\;per\;year}\right) = 1.78E-7 \text{ per year}$$

The licensee assumed that a pipe failure occurs during a 7-day rainfall scenario (i.e., 2-day pre-storm, 3-day no rain, and 2-day main rainfall, in sequence), while 1000-year rainfall is for the 3-day duration. At the site audit, the NRC staff requested the licensee to clarify the discrepancy between the rainfall depths used in the PRA. In its supplement, the licensee clarified that the consequence of dike failure due to rainfall is assumed to be the same regardless of the severity of the rainfall event as they used frequency of rainfall, not depth. The licensee indicated the probability of the dike failure would be decreased if they use the probability of the occurrence of a probable maximum precipitation (PMP) event, which has exceptionally rare occurrence.

When the NRC staff considered an increase in the rainfall duration (9-day rainfall scenario), the above dike failure probability will be increase moderately (2.29E-7) but would still be in the same order of magnitude. Therefore, the NRC staff finds the licensee's estimate of dike failure not significantly sensitive to rainfall duration and the frequency is, therefore, acceptable.

3.2.4.1 Dependent Failure Scenario

Piping failures of embankment dikes often initiate from leaks around buried culvert or drainpipe. The staff initially postulated that leaks from FPS or DWS pipe during the normal (non-flooding) time could create a seepage line along the drainpipe underneath the dike due to water from pipe leaks accumulating around the drainpipe. This seepage condition could lead to subsidence or rupture of the dike. This process could be exacerbated during a severe lake flooding with increased internal pressure of the dike. In this case, PMP-induced flooding and pipe failure events are dependent. The probability of this combined scenario, which is governed by the probability of generic dike piping failure (i.e., approximately 10E-4), will increase compared to that of the independent case. In its supplement, the licensee justified that such a dependent failure scenario is moot due to site conditions and leak monitoring plans as discussed in Subsection 3.2.3 that would be able to detect such a situation before it was consequential. Correspondingly, the NRC staff determines that the dependent failure of pipe and dike failure is not plausible.

3.2.4.2 Conclusion of Risk Analysis

To assess the increased contribution to plant risk of the vulnerability to dike failure, the estimated frequency of an independent Lake Anna flood after an FPS pipe rupture/failure event of 1.78 E-7 per year is evaluated using the criteria in Regulatory Guide (RG) 1.174 (Reference 13). It is assumed that a catastrophic flood would result in a contribution to the Core Damage Frequency (CDF). Any mitigation actions taken by the licensee to reduce this quantitative risk estimate further (including FLEX) were not credited. Since North Anna has a sub-atmospheric large dry containment, the licensee assumed that a catastrophic flooding event will not increase the impact of contributors to the Large Early Release Frequency (LERF) as much as CDF. Therefore, using the acceptance guidelines of Figures 4 and 5 of RG 1.174, the coincidently independent external flood and failure of the dike is categorized as having a very small change to risk.

3.2.5 Proposed Dike Inspection and Flood Mitigation Strategies,

The licensee stated that, if a pipe was to leak or rupture within the flood protection dike, the leak would be detected. It is possible because (i) a small leak would cause the face of the flood protection dike to dampen and (ii) a pipe rupture would cause visible seepage and possible soil erosion. The licensee stated that, since the domestic water system pipe is 2 inches in diameter, a rupture would not wash out the flood protection dike, but the failure would quickly become apparent, and the rupture would be detected and repaired before a flood protection dike failure would occur. They also said that, if the 12-inch fire protection system pipe was to rupture, considerable damage to the flood protection dike would occur if the rupture continued undetected. However, this is very unlikely since North Anna has the following methods of detecting a fire protection system pipe break or leak and plant personnel would be able to isolate the break in a timely fashion:

- Security would notice significant differences (wetness or pooling) in the appearance of the flood protection dike during routine patrols performed several times each day. Security officers are trained to notify Operations if erosion or moisture is observed on the dike, if it appears to be coming from the underground piping system. Weekly camera inspections are performed which provide an opportunity to observe the western slope of the dike.
- The flood protection dike is landscaped at least twice a year. Individuals in the area of the dike during landscaping activities would be expected to identify abnormal conditions to the dike.
- Small leaks of both pipe sizes would be detected during the annual flood protection dike inspection.
- A fire protection system piping leak or rupture would result in increased cycling of the fire protection hydropneumatic tank level and pressure, which are monitored daily by operations. Furthermore, the pressure maintenance pump would be cycling to maintain the dropping tank pressure. Significant leakage (>30 gpm) would auto start a main fire pump and alert the operators in the control room, triggering an investigation. In addition,

operators monitor the fire protection hydropneumatic tank once per shift. The fire protection tank level is verified between 10 and 80% in the level gauge, and pressure is verified between 104 psig and 120 psig.

- Operators perform quarterly and annual periodic tests which cycle the fire protection system valves at the ends of the flood protection dike, which provides an additional opportunity to observe signs of leakage on the western bank of the flood dike.
- Operator rounds provide daily checks of domestic water well house tank level (visible within the level gauge) and pressure. Pressure is observed to be within a range of 45 psig to 85 psig.
- An abnormal procedure is in place and contains requirements for site response to storm/hurricane warnings. The procedure includes instructions for securing items around the site, monitoring wind speed and storm surge, and preparing and monitoring for possible localized flooding.

The NRC staff agrees that small leak detection during drier weather conditions could be adequately detected by the various methods described above. The NRC staff believes that a small leak from pipes may not be detected effectively during the heavy rainfall condition with flooding that lasts approximately six hours. In this case, water from the leak will seep out the upstream face of the dike, resulting in a loss of the backfill section of the upper west corner of the dike. This scenario, however, is the same as the Dominion-simulated excavated dike cross-section condition for the licensee's slope stability analysis, for which the dike system has enough factors of safety with the remaining portion of the dike. Therefore, the NRC staff screens out this failure scenario.

3.3 Structural Integrity of the Dike

In Reference 1, the licensee stated that a 10 ft. wide, 4.5 ft. deep trench on the western side of the flood protection dike was excavated to facilitate the buried piping installation. Figure 1 of Reference 1 shows a 3 ft. wide by 3 ft. deep trench extending the entire length of the dike was excavated on the western slope and part of the crest of the dike to allow installation of the 12-inch ductile iron fire protection system (FPS) pipe and 2-inch high density polyethylene (HDPE) domestic water system pipe. During the site audit, the NRC staff asked the licensee to provide the horizontal distance from the center line of the 12-inch FPS piping to the west side of the dike. In its supplement, the licensee stated that, based on a field survey performed on July 17, 2019, they identified the fire protection piping located approximately 6 to 7 feet deep from the top of the dike crest, and approximately two to six feet east from the western crest edge of the dike as shown in Reference 2, Attachment 2.

During the site audit, the NRC staff requested the licensee's procedures used to install the pipes within the flood protection dike in 2013. In its supplement, the licensee stated that the fill placement and compaction was performed in accordance with the specifications for excavation, backfill, and compaction of trenches applicable to the safety-related nuclear facilities from the original Design TS for North Anna.

The results of the soil prequalification testing and soil placement testing are documented in the AMEC Compilation Testing Report for Utility Backfill Testing Flood Protection Dike. The AMEC report documents that the fill placement meets the requirements of the NAI-0003. However, from the AMEC report, the NRC staff noticed that there are some test data in the testing report that are "outside" of the specified range for safety-related backfills. In its supplement, the licensee stated that soil compaction specifications are established based on the type of soil and proposed use, and the moisture-density relationship developed with either the ASTM Standard

D698 or ASTM Modified D1557. These tests differ by the amount of compaction energy applied to a specified soil volume with the higher compaction energy test (Modified) resulting in a higher dry density in the compacted specimen. The optimum moisture content is the water weight to dry soil weight ratio (%) at which the compacted soil specimen achieves its maximum dry density relative to the compaction energy input of the specific test. The licensee also stated that the important factor to note here is relative to the compaction energy, because a properly placed fill can experience higher compaction energy during construction than in the lab. The specification for the flood protection dike construction acknowledges this and states, "The moisture content is not considered most critical to the performance of the completed dike. The compact percentage is the critical item and the specified moisture range is only intended as a guideline to achieve adequate compaction." The specification indicates that when the percentage compaction is 95 percent or greater and falls outside the listed moisture content range, the testing agency representative is to notify dike owner. The testing agency noted on the inspection reports that it provided to the owner notification of when the moisture was "outside the specified range".

Based on the above, the NRC staff finds the structural integrity of the flood protection dike after the 2013 modification has not been impaired because the fill placement and compaction were performed in accordance with design specification.

3.4 Proposed UFSAR Changes

The NRC finds that the proposed UFSAR changes below are consistent with the 2013 design change to the safety-related flood protection dike as previously described above. This includes:

- Section 3.11.3, Corrosion Prevention for Underground Piping, shows the addition of cement-lined ductile iron fire protection system piping (previously, only cast-iron material was used for fire protection system piping).

- Table 9.2-10, Domestic Water Supply Component Design Data, deletes an abandoned well #4 and add data for well #8.

    - Design pressure: 527 ft TDH replaced 500 ft TDH
    - Well depth: 400 ft replaced 305 ft

- Section 9.5.1.1, Design Basis, no longer refers to the Site Construction Office Building North (SCOBN) Sprinkler System. The SCOBN building has been abandoned, and the underground fire protection supply piping to the SCOBN was abandoned with that modification.

- Section 9.5.1.2.1, Fire Protection Water Systems, removes the reference to the underground fire protection loop going around the area formerly for Unit 3. The underground fire protection system piping in this area was abandoned by the modification.

- Figure 9.5-1, Fire Protection System Arrangement, depicts the new routing of the underground fire protection system piping.

The NRC staff finds these five UFSAR changes accurately describe the 2013 design change, as discussed above, related to corrosion prevention, domestic water supply wells, sprinkler system within the SCOBN, abandoned fire protection system loop, and fire protection system arrangement and are, therefore, acceptable.

3.5 NRC Staff Technical Evaluation Summary

The licensee stated that the installed pressurized water sources have a very small impact on the reliability of the flood protection dike to perform its external flood protection function. They also concluded that the probability of the flood protection dike's inability to provide flood protection due to a pressurized pipe rupture is very low and is conservatively estimated to be approximately 1.78E-07. As discussed in the PRA, they stated significant damage to the flood protection dike due to a pipe rupture is unlikely to occur prior to detection.

The licensee concluded the current configuration of the flood protection dike with the 12-inch fire protection system piping and 2-inch domestic water system piping routed within the western edge is acceptable. This conclusion is based on the following:

a) North Anna has ample observers, walkdowns, periodic tests, alarms, readings and other indicators to detect a major break in either of the two non-safety-related pipes in the safety-related flood protection dike,
b) isolation valves are provided for the piping within the flood protection dike to allow isolation in the event of a leak, and these valves will remain accessible during a PMF,
c) the Slope Stability Analysis and PRA analysis determined that the probability of the flood protection dike losing its flood protection function due to a pressurized pipe rupture is extremely low,
d) The structural integrity of the flood protection dike after the 2013 modification has not been impaired because the fill placement and compaction were performed in accordance with the design specification.
e) no known code or standard prohibits the pipe installation, and
f) General Design Criteria 3 and 4 are satisfied through identification and isolation.

Based on the review of the LAR and related information provided through the site audit process, the NRC staff concludes the conclusion related to the risk analysis is acceptable because the risk analysis follows the current NRC guidance.

Based on the above, the proposed changes to the North Anna UFSAR are acceptable.

4.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Commonwealth of Virginia official was notified of the proposed issuance of the amendments on October 11, 2019. The state official confirmed that the Commonwealth had no comments.

5.0 ENVIRONMENTAL CONSIDERATION

The amendments change requirements with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20 and change surveillance requirements. The NRC staff has determined that the amendments involve no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendments involve no significant hazards consideration, and there has been no public comment on such finding published in the *Federal Register* on March 26, 2019 (84 FR 11334). Accordingly, the amendments meet the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendments.

6.0 CONCLUSION

The NRC staff has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) there is reasonable assurance that such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendments will not be inimical to the common defense and security or to the health and safety of the public.

7.0 References

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Date: November 13, 2019

SUBJECT: NORTH ANNA POWER STATION, UNIT NOS. 1 AND 2 – ISSUANCE OF AMENDMENTS REGARDING INSTALLATION OF WATER HEADERS IN FLOOD PROTECTION DIKE (EPID L-2018-LLA-0485) DATED NOVEMBER 13, 2019

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RidsNrrLAKGoldstein Resource
RidsNrrPMNorthAnna Resource
RidsNrrDssScpb Resource
RidsNrrDirsIrab Resource
RidsNrrDeEseb Resource
RidsNrrDraApla Resource

ADAMS Accession No. ML19274C998 ***via SE Input **Via E-mail**

OFFICE	NRR/DORL/LSPB/PM	NRR/DORL/LPL2-1/LA	NRR/DIRS/IRAB/BC	NRR/DSS/SCPB/BC(A)
NAME	GEMiller	KGoldstein	AMasters**	SJones**
DATE	11/06/19	10/09/19	10/03/19	10/11/19
OFFICE	NRR/DE/ESEB/BC(A)	NRR/DRA/APLA/BC	NRO/DLSE/EXHB/BC	OGC - NLO
NAME	JColaccino**	RPascarelli**	DBarnhurst**	KGamin
DATE	10/16/19	10/21/19	10/21/19	11/05/19
OFFICE	NRR/DORL/LPL2-1/BC	NRR/DORL/LSPB/PM		
NAME	MMarkley	GEMiller		
DATE	11/13/19	11/13/19		

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