ENERGY NORTHWEST

COLUMBIA GENERATING STATION
RICHLAND, WASHINGTON

Flood Protection Final Report

IN RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST REGARDING NEAR-TERM TASK FORCE RECOMMENDATION 2.3: FLOODING

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I. INTRODUCTION

In response to the accident at the Fukushima Dai-ichi nuclear power plant caused by the March 11, 2011, Tohoku earthquake and subsequent tsunami, the U.S. Nuclear Regulatory Commission (NRC) established the Near-Term Task Force (NTTF) to conduct a systematic review of NRC processes and regulations, and to make recommendations to the Commission to clarify and strengthen the regulatory framework for protection against natural phenomena.

The purpose of Columbia Generating Station's (CGS) Flood Protection Final Report is to address those items identified in the Requested Information section of 10 CFR 50.54(f) Enclosure 4, Recommendation 2.3: Flooding. The flooding walkdowns were performed by Energy Northwest's staff and contractor (ENERCON) during the week of August 13, 2012. Walkdowns were conducted utilizing the guidelines established in Nuclear Energy Institute (NEI) 12-07, Rev. 0-A, May 2012, Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features, endorsed by the NRC Letter, May 31, 2012.

CGS is located on the Department of Energy (DOE) Hanford Reservation within Benton County, Washington, approximately 3 miles west of the Columbia River and 10 miles north of Richland, Washington.

There are no flood protection features or flood mitigation procedures credited in existing Current Licensing Basis (CLB) documents for protection and mitigation against external flooding events at CGS because CGS is considered a "Dry Site". This type of site is a result of safety-related Structures, Systems, and Components (SSCs) being built above the Design Basis Flooding Level (DBFL) by terrain, per REG Guide 1.102 Flood Protection for Nuclear Power Plants, Section B.1 Dry Site.

Energy Northwest chose to visually inspect penetrations at below grade exterior walls for the Reactor Building and the Standby Service Water Pumphouses, although they are not credited in the CLB documentation as flood barriers.

II. DESIGN BASIS FLOOD

A. Basis

1. Assumptions

   During the walkdown, the site's topography and structures were visually reviewed for any changes incorporated at the plant site since the CLB documents. Although no extensive changes to finish grading were observed, this walkdown report assumes that CLB

documentation relative to topographical and finish floor elevations for existing buildings are accurately depicted.

2. Methodology

The following flood-design bases were used to develop the methodology in performing the flooding walkdowns:

a. The probable maximum precipitation (PMP) event equals the elevation (el.) of 431.1 feet mean sea level (msl). The design-basis flood (DBF) elevation equals 433.3 feet msl, including an additional 2.2 feet to account for coincident wind wave action. The plant is built (at el. 441 feet msl) above the DBFL; therefore, safety-related structures, systems, and components are not affected by flooding.

The PMP event for the site has been determined using the methodology developed by the U.S. Weather Bureau, which evaluates the combined convergence precipitation and orographic precipitation of a general storm, and separately studies the thunderstorm precipitation since it is determined to be more severe than a general storm's precipitation. The Thunderstorm PMP Hydrograph totals 9.2 inches in a six-hour period. The entire site drains easterly unobstructed to a broad channel that extends in a north-south direction for about 7 miles and varies in width from 2,000 feet to over one mile. The design-basis flood for the CGS site area results from the adjacent drainage basin runoff from northwest of the plant down to the low area southeast of the plant, and not from flooding of the Columbia River.

b. The probable maximum flood (PMF) event resulting from the breaching of the Columbia River's Grand Coulee Dam, which is approximately 245 river miles upstream of the CGS site, is at el. 422 feet msl. The limiting case flood (LCF) is at el. 424 feet msl, including 2 additional feet for wind wave action.

The Seattle District Army Corps of Engineers determined artificial flood levels at the CGS site assuming the following concurrent conditions: a sudden Grand Coulee Dam failure caused by massive explosives; the Columbia River is at flood stage; and reservoirs at all storage pools below the dam are full. A seismic failure or overtopping of the dam would not create flood level conditions as severe as the sudden catastrophic failure scenario.

Energy Northwest screened out the PMF at el.422 feet msl (LCF at 424 feet msl) because it is not the limiting flood and does not challenge any flood mitigation features due to this level being well below the DBFL of el. 433.3 feet msl.

c. Under the CGS site the unconfined groundwater moves easterly toward the Columbia River. Soil test borings and water supply wells on the CGS site confirm the water table is approximately 60 feet below the ground surface, at el. 378 $\pm$ 4 feet msl. The design-basis groundwater is at el. 420 feet msl and is based on studies of proposed construction of the Ben Franklin Dam (which has not been built), spray pond leakage, and pipe leakage on site.

   Seismic Category I safety-related SSCs are located above the present groundwater el. 380 feet msl and are not subject to any force effects of buoyancy and static water from this groundwater elevation. Uplift and increased lateral hydrostatic pressure are considered in the design of all Seismic Category I structures and safety-related systems and components, to ensure their safety in the event of a rise in the groundwater table to el. 420 feet msl. Standby Service Water Pumphouses 1A and 1B are designed to resist the increased hydrostatic pressure which would result from the rise in the groundwater to el. 420 feet msl. The lowest floor surface in the reactor building is the top of the foundation mat at el. 422 feet-3 inches msl. Since this is above the design basis groundwater level, the structure is unaffected by the force effects of buoyancy and static water due to groundwater at el. 420 feet msl. Groundwater el. 420 feet msl was compared with foundation levels of Seismic Category I structures and it was determined that waterproofing is not required. Seismic Category I piping and electric conduit penetrations that are below grade are above the design basis groundwater table, and sealing against groundwater pressure is therefore not required. However, all pipes penetrating exterior walls are waterproofed and sealed by boots installed on both sides of the wall penetration; electrical conduit penetrations are through-wall waterproof sealed using silicon foam.

   Energy Northwest screened out the design-basis groundwater at el. 420 feet msl because it is not the limiting flood and does not challenge any below grade flood mitigation features.

d. Energy Northwest screened out the flooding hazard due to Columbia River ice blockage since, historically, the Columbia River has never experienced complete flow stoppage or significant

flooding due to ice blockage. Due to the frequent fluctuations of the water level of the Columbia River as regulated by upriver dams, long-term ice damming or ice sheeting does not occur at river plant water intake locations.

e. The safety-related structures (the Reactor Building, the Diesel Generator Building, the Radwaste Control Building, the two Standby Service Water Pumphouses), and the associated Systems and Components on the CGS site are built with adjacent finished grade at 440 feet msl. The access openings to the safety-related structures are located well above all flood water elevations, including that of wind and wave action; therefore, the site is defined as a "Dry Site" and is not affected by flooding.

   Energy Northwest screened out the sub-grade portions of the safety-related structures because there are no credited flood mitigation features below the el. of 441 feet msl.

f. Per topographic survey, the concrete slab for the Independent Spent Fuel Storage Installation (ISFSI) is constructed above flood levels at el. 447 feet msl (136.25 meters) on the north end of the plant. This is above the elevations of all DBF scenarios.

g. The CGS site is not adjacent to a coastal area and is, therefore, not vulnerable to tsunami flooding or storm and tidal surge.

h. The upper 40 feet of the site's soil profile are dry loose to medium dense, fine to coarse sand with scattered gravel, which were removed and recompacted as structural fill. The site is situated near the middle of the relatively flat, essentially featureless plain, with sagebrush interspersed with perennial native and introduced annual grasses extending in a northerly, westerly, and southerly direction for several miles. The plain is characterized by slight topographic relief of approximately 20 feet across the plant site.

3. Flood Hazard Levels

   In addition to the walkdowns of the safety-related structures, the walkdown visual inspections compared current plant modifications to CLB documentation. Additions and removal of structures, paved surfaces, and corresponding topographical changes were considered for their effect on site drainage. No increases or contradictions in flood hazard levels relative to licensing basis documentation were noted by walkdown visual inspection.

B. Protection and Mitigation Features

1. Modes of Operation

   a. The safe shutdown of the reactor is neither thwarted by a PMP nor a PMF event since safety-related SSCs and personnel access openings to all safety-related facilities are located above these flood limits.

   b. During normal full-power reactor operation, the cooling water necessary for the plant is supplied from the six cooling tower basins. The cooling towers' areas, circulating water pump house, and electrical buildings are positioned above flood levels at adjacent finished grade elevations varying from approximately 445 feet msl to 447 feet msl.

   c. The two spray ponds contain a 30-day supply of water and serve as the ultimate heat sink for normal reactor cooldown and for emergency cooling. The spray distribution systems in each spray pond are redundant, and each spray distribution system is capable of providing sufficient cooling to safely shut down the plant. The finished grade around the spray ponds is above flood levels at el. 434 feet msl and the top of the ponds' concrete walls are at el. 435 feet msl. Both ponds have an overflow weir at el. 434.5 feet msl.

   d. The flooding of the makeup water pumphouse located at the Columbia River bank would not affect safety-related equipment and would not affect the safe shutdown of the plant.

2. Flood Duration

   a. The duration of a flooding event is not applicable for this dry site and is not a flooding hazard. Momentary ponding from a PMP event is drained via roadways, culverts, drainage ditches, surface flow, and catch basins. The drainage features and topography are mapped in the CLB.

   b. With a failure of the Grand Coulee Dam, the arrival of the flood wave at the area of the CGS is estimated to be 23 hours and the flood peak at 38 hours. CGS is approximately 245 miles from the dam.

   c. The thunderstorm PMP of 9.2 inches total in a six-hour period would produce a peak discharge in 7.5 hours at the DOE highway 2.8 miles south of the plant where it crosses the drainage basin.

   d. Precipitation losses through ground infiltration have been estimated at the site areas to be 1.5 inches per hour. With an

average antecedent moisture condition assumed, the 60-minute retention loss rate is 0.15 inches per hour. Due to this rapid infiltration rate, by past plant experience, localized rain events do not pond excessively and consequently these events are not a hazard to the safety-related SSCs.

3. Protective Flood Features

   a. Emergency preparations have a timeline of approximately 7.5 hours to receive offsite shipments and personnel via the DOE highway in a PMP event. The Grand Coulee Dam breach event limits about 23 hours to prepare for the PMF event. The Plant Procedures Manual lists four alternate access routes to CGS, if the DOE Highway access is flooded.

   b. The most severe PMP is determined to be from thunderstorm precipitation which totals 9.2 inches in a six-hour period. Roofs are designed to take, with adequate drainage, any instantaneous or local intense precipitation. Roofs of safety-related buildings that do not have overflow relief are designed to carry the entire PMP if all roof drains should be clogged. In addition, some roofs are equipped with overflow scuppers to limit the depth of rooftop water accumulation. Water from roof drains is discharged via an underground storm pipe system to a low point east of the plant island.

      Energy Northwest chose to visually inspect the eight rooftop equipment access hatches on the Diesel Generator Building. The hatches are not credited as a flood-related feature since the hatches are installed on a concrete rooftop curb that is approximately 12 inches high above the roof surface. The PMP total rainwater event of 9.2 inches will not achieve that elevation to overtop the curbs. Three thru-parapet scuppers are installed to relieve excessive ponding on the Diesel Generator Building's roof should roof drains become blocked.

      In lieu of performing inspections of the building roofs under this walkdown scope, credit was taken for the existing structural monitoring program, which periodically inspects roofs for damage and degradation.

c. The general site is naturally graded from high ground at the northwest to lower elevations at the southeast toward the Columbia River, 3 miles east of the plant. Surface flow is generally around and away from the Protected Area (PA) plateau areas where the safety-related SSCs are located.

d. To accommodate localized surface drainage throughout the plant island and parking areas, a system of catch basins and dry wells is provided with inlet elevations a minimum of 6 inches lower than the nearest roadway and 12 inches below the nearest building's finished floor slab elevation.

e. Runoff from the PMP event is accommodated by designing the roadways such that the high point of the road is 6 inches to 1 foot below the finished floor elevation of the adjacent safety-related buildings. Runoff from this event is from the northwest to the southeast across the site plateau to the low area southeast of the plant site. The general plant site is nominally 9 feet above the maximum calculated water surface elevation resulting from the postulated PMP. Therefore, the site grading precludes the potential flooding of safety-related structures.

4. Adverse Weather Conditions

Temporary active and temporary passive flood protection measures are not required for protection of safety-related SSCs during flooding conditions; therefore, manipulation of special flood-related systems or components in outside areas of the plant concurrent with adverse weather conditions is not necessary.

C. Warning Systems

No localized flood level warning systems are needed for CGS, due to the high elevation of all safety-related systems. No interior water level warning systems or alarms are credited for flood protection function in the plant external flooding licensing basis.

D. Flood Protection Effectiveness

1. The worst hydrological condition is a flood caused by a postulated PMP event. This flood does not create an adverse hydrological condition on safety-related SSCs. No advance preparations of emergency flood-related equipment are credited in the CLB as mitigation or protection features for flooding hazards.

2. No washouts or significant areas of erosion were found. Concrete, asphalt, and gravel paved areas are well maintained and no degraded areas were observed.

3. Although not credited in the CLB for external flood mitigation, storm catch basins are positioned to intercept localized precipitation in generally level areas. By walkdown visual inspection of these drains, they were clear of debris, not damaged, and at a lower elevation than the immediate surrounding grade for effective drainage.

4. Although not credited in the CLB for external flood mitigation, the below grade floor level of the Reactor Building is equipped with multiple sump pumps. The pump rooms are served by these sump pumps which are monitored in the Control Room. Also, there is safety-related flood detection in the ECCS and RCIC pump rooms that is designed to alert operators of a flood. Steel flood doors separate the pump rooms to isolate flooding conditions. If any water should infiltrate into this below grade level, these sump pumps will provide additional protection from an exterior flood source.

III. WALKDOWN

A. Performance

1. Acceptance criteria of NEI 12-07 were utilized to determine the effectiveness of any flood protection features. The walkdowns were performed in accordance with the NRC endorsed guidance provided in NEI 12-07 Rev. 0-A, without exceptions. The NEI 12-07 Appendix B-Walkdown Record Form template was utilized. In addition, a job-specific documentation template was developed for consistent and efficient review of walkdown findings.

2. Two walkdown groups were each formed with two or three qualified personnel and were accompanied by persons knowledgeable of the plant configurations.

   One group visually inspected the condition of safety-related structures' interior penetrations at the following locations: the four exterior walls of the basement level of the Reactor Building; the common wall between the basement levels of the Service Building and the Reactor Building; the Diesel Generator Building's roof hatches; and the two Standby Service Water Pumphouses adjacent to the two Spray Ponds.

   The second group visually inspected all exterior areas of the plant site within the perimeter concrete security barrier. The exterior walkdown

visually inspected for new modifications added since the CLB, topography changes since the CLB, and obstructions to stormwater drainage design. Buildings were listed in the walkdown template to identify areas of inspection. The interiors of non-safety-related buildings were not inspected since the function and contents of these structures are not included in the flood hazard analysis.

3. The flooding walkdown inspectors satisfactorily completed the recommended training outlined in NEI 12-07 Rev. 0-A, Appendix C-Sample Training Content. The inspectors received the Energy Northwest Qualification Certificate for Flooding Walkdown Engineer, and successfully completed the NANTEL Flood Protection Walkdowns course.

B. Results

1. The safety-related SSCs are built within the PA and at the Standby Service Water Pumphouses at the finished floor slab of el. 441 feet msl. Below-grade areas in the Reactor Building are at slab el. 422 feet-3 inches msl, and below-grade areas in the Pumphouses are at 431 feet msl. Penetrations in the Reactor Building's below-grade concrete walls were visually observed as sealed, and design-basis groundwater (420 feet msl) is below this level so no hydrostatic loading is applied to these seals. Penetrations in the Standby Service Water Pumphouses exposed to the DBFL el. of 433.3 feet msl were noted as sealed. Penetrations located below grade el. 441 feet msl at exterior walls are above the groundwater el. of 420 feet msl. In the safety-related structures, exterior concrete walls showed no cracking equal or greater than 0.04 inches that challenged the ability to withstand water infiltration.

2. No flood protection features were excluded from the walkdowns. No degraded, non-conforming, or unanalyzed conditions credited for flood protection were identified by the walkdown visual inspection. There were no flooding hazard findings or actions that required entry into the corrective action program (CAP). There are no exterior incorporated or temporary flood barriers or advance preparations of emergency flood-related equipment credited in the CLB for CGS.

3. Site topography was noted to maintain overall natural drainage profiles of the original CLB. No washouts or significant areas of erosion were found. Concrete, asphalt, and gravel paved areas are well maintained and no degraded areas were observed. The perimeter concrete security barrier is not a hazard or obstruction relative to flooding.

4. The walkdown visual inspections of site modifications and building flood protection measures required per the NRC-endorsed flooding walkdown guidelines were satisfactorily accomplished. There was no restricted access or inaccessible features concerning flood-related inspections.

5. Energy Northwest chose to visually inspect accessible below grade penetrations, walls, and floors in the Reactor Building and the Standby Service Water Pumphouses, which house the SSCs important to safety. Below grade walls, floors, and penetration seals that were visually inspected were found to be in good condition, with two exceptions. There were two conduits in one of the Standby Service Water Pumphouses that did not have a visible seal viewed from the building side; the other side was in a buried duct bank and was not accessible. The interiors of the conduits were clean and there was no dirt, corrosion, debris, or evidence of water or insect intrusion from the outside. These exceptions are not deficiencies as defined in NEI 12-07 because the conduit seals are not credited to perform an intended flood protection function. These two conduits are located above the design-basis groundwater elevation.

C. Available Physical Margin

The Available Physical Margins have been collected and documented in the Walkdown Records as instructed per NEI 12-07, Appendix D, Section g. The APMs will be evaluated relative to cliff-edge effects and the associated safety risks during the Recommendation 2.1 assessments. No areas of limited APM were located during the walkdowns.

D. Changes

As a result of the walkdowns and peer review, there are no planned or newly installed flood protection systems or flood mitigation measures including flood barriers that further enhance the flood protection.

IV. CONCLUSIONS

According to the U.S. NRC Regulatory Guide 1.102, Revision 1, September 1976, the CGS site is a "Dry Site" since the plant is built above the DBFL;

therefore, the safety-related Structures, Systems, and Components are not affected by flooding. The Powerblock's safety-related SSCs are constructed on natural terrain and engineered fill to uniformly grade the immediate area, and are not affected by flooding. The ISFSI area is also located above the DBFL. Site topography continues to provide the overall drain profiles assumed in the flood hazards analysis.

According to procedures and methodology written in Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features, NEI 12-07 (Rev. 0-A), May 2012, and 10 CFR 50.54(f) Enclosure 4, NTTF Recommendation 2.3, the walkdown visual inspection has verified that the CGS permanent safety-related SSCs are acceptable, not degraded, and capable of performing their design function as credited in the CLB.

The walkdown visual inspection has verified that plant modifications implemented since original construction and under the CLB have not adversely affected plant flooding protection from design-basis groundwater, the PMP, and the PMF events.

During a flood event, the plant does not require emergency flood protection measures and the reactor can be placed in a safe shutdown mode. Since the plant does not require flood protection procedures for flood protection features, reasonable simulation was not required. There is adequate time to prepare for adverse weather conditions or a flood event since the safety-related SSCs are built above the DBFL. In addition, there are several alternate routes to access CGS which are published in the Plant Procedures Manual.

V. REFERENCES

V.1. U.S. Nuclear Regulatory Commission, Letter Dated March 12, 2012, Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force (NTTF) Review of Insights from the Fukushima Dai-ichi Accident; NTTF Recommendation 2.3 Flooding, Enclosure 4

V.2. U.S. NRC Regulatory Guide 1.102, Flood Protection for Nuclear Power Plants, Revision 1, Sept. 1976, Section B.1 Dry Site

V.3. Nuclear Energy Institute (NEI) 12-07, Rev. 0-A, May 2012, Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features; NRC Letter of Endorsement of NEI 12-07, Rev. 0-A, May 31, 2012