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September 20, 2017
L-17-259

10 CFR 50.54(f)

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
11555 Rockville Pike
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SUBJECT:
Beaver Valley Power Station, Unit Nos. 1 and 2
Docket No. 50-334, License No. DPR-66
Docket No. 50-412, License No. NPF-73
Mitigating Strategies Assessment (MSA) for Flooding (CAC Nos. MF3286 and MF3287)

On March 12, 2012, the Nuclear Regulatory Commission (NRC) issued a letter titled, "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 Review of Insights from the Fukushima Dai-ichi Accident," to all power reactor licensees and holders of construction permits in active or deferred status. Enclosure 2 of the 10 CFR 50.54(f) letter addresses Near-Term Task Force (NTTF) Recommendation 2.1 for flooding. One of the required responses is for licensees to submit a hazard reevaluation report (HRR) in accordance with the NRC's prioritization plan. By letter dated March 2, 2016, FirstEnergy Nuclear Operating Company (FENOC) submitted the flood HRR for Beaver Valley Power Station (BVPS), Unit Nos. 1 and 2. As indicated in NRC letter dated March 1, 2013, the NRC staff considers the reevaluated flood hazard to be "beyond the current design/licensing basis of operating plants."

Concurrent to the flood hazard reevaluation, FENOC developed and implemented mitigating strategies in accordance with NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events." By letter dated September 1, 2015, the NRC staff confirmed that licensees need to address the reevaluated flooding hazards within their mitigating strategies for beyond-design-basis (BDB) external events. Guidance for performing mitigating strategies assessments (MSAs) for reevaluated flooding hazards is contained in Appendix G of Nuclear Energy Institute 12-06, Revision 2, which was endorsed by the NRC in JLD-ISG-2012-01, Revision 1. In the NRC interim staff assessment for BVPS, dated February 22, 2017, the NRC concluded that the "reevaluated flood hazard information, as summarized in Table 2 of the enclosure [Summary of Results of Flooding Hazard Re-evaluation Report], is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049" for BVPS.

The enclosure to this letter provides the MSA for flooding for BVPS. This assessment indicated that the FLEX strategies, with implementation of a minor change, are adequate and can be implemented without impact from the local intense precipitation (LIP) flood and combined effects flooding (CEF), including wind-generated waves.

There are no new regulatory commitments contained in this letter. If there are any questions or if additional information is required, please contact Mr. Thomas A. Lentz, Manager – Fleet Licensing, at 330-315-6810.

I declare under penalty of perjury that the foregoing is true and correct. Executed on September 20, 2017.

Sincerely,

Richard D. Bologna

Enclosure:
Mitigating Strategies Assessment for Flooding

cc: Director, Office of Nuclear Reactor Regulation (NRR)
NRC Region I Administrator
NRC Resident Inspector
NRR Project Manager
Director BRP/DEP
Site BRP/DEP Representative

Enclosure
L-17-259

Mitigating Strategies Assessment for Flooding
(18 pages follow)

# Beaver Valley Power Station
# Mitigating Strategies Assessment for Flooding

**Acronyms:**

- DB - Design Basis
- ELAP – Extended Loss of AC Power
- FHRR - Flood Hazard Reevaluation Report
- FIP - Final Integrated Plan
- FLEX - Diverse and Flexible Coping Strategies
- LIP - Local Intense Precipitation LUHS - Loss of Normal Access to the Ultimate Heat Sink
- MSA - Mitigating Strategies Assessment
- MSFHI - Mitigating Strategies Flood Hazard Information (from the FHRR and MSFHI letter)
- MSL - Mean Sea Level
- NORM - Nuclear Operating Reference Material
- NSRC - National SAFER Response Center
- PMF - Probable Maximum Flood
- UFSAR - Updated Final Safety Analysis Report

**Definitions:**

**FLEX Design Basis Flood Hazard** - The controlling flood parameters used to develop the FLEX flood strategies.

**FLEX** - Diverse & Flexible Coping Strategies

- **Phase 1** - Initially cope by relying on installed plant equipment.
- **Phase 2** - Transition from installed plant equipment to the on-site FLEX equipment.
- **Phase 3** - Obtain additional capability and redundancy from off-site equipment until power, water, and coolant injection systems are restored or commissioned.

**FLEX N Equipment** - Equipment used is protected from all beyond design basis hazards and is the primary FLEX response equipment.

**FLEX N+1 Equipment** - Equipment used is NOT protected from all beyond design basis hazards and is used as an alternate to FLEX N equipment.

**FLEX NSRC Equipment** - Equipment provided by the NSRC to support FLEX Phase 3 strategy.

**Unit abbreviations**:

ft – feet

ft/sec – feet per second

## 1. Summary

The Mitigating Strategies Flood Hazard Information (MSFHI) provided in the Beaver Valley (BVPS) Flood Hazard Reevaluation Report (FHRR) concluded that the local intense precipitation (LIP) and combined effects flooding, including wind-generated waves (CEF), can potentially challenge implementation of the FLEX strategies. Based on the completed Mitigating Strategies Assessment (MSA), NORM-LP-7121, after implementation of a minor change the FLEX strategies are shown to be adequate and can be implemented without impact from the identified MSFHI. Other reevaluated flood hazard mechanisms (i.e. tsunami, channel migrations/diversions, etc.), are bounded by the plant design basis and have no impact on the site.

The MSFHI LIP flood levels develop a depth above several critical door sills for a limited period. The results of the MSA show that the LIP event will cause some difficulties with FLEX equipment deployment and remove some flexibility due to deployment route and staging area flooding. Impacts to the availability of offsite personnel could also challenge FLEX implementation. Due to margin in the FLEX timeline and the availability of designed alternate routes, FLEX can be implemented as designed with only one exception. Based upon the FLEX deployment strategy one flooded door is required to be open. This requires that an additional flood protection barrier be installed on an adjacent door to prevent internal flooding.

The MSFHI CEF event is a slow developing event, with several days of warning and preparation time. The existing abnormal operating procedures would require the shutdown of both Units well in advance of the CEF event. As described in the MSFHI letter, the design basis still water elevation (730.0 ft) is utilized in this assessment instead of the value submitted in the FHRR (727.53 ft). The flooding resulting from the CEF exceed the design basis but does not adversely affect safety related structures. FLEX implementation is achievable in non-flooded areas. It is recognized that the CEF event may require utilizing alternate deployment paths and staging locations but they are already described in the existing FLEX strategy. FLEX equipment storage buildings, the NSRC staging area and the equipment deployment routes to the site are at higher elevations and unaffected by the CEF event.

The FLEX response timeline has been reviewed and verified to ensure FLEX strategies can be implemented to address the LIP and CEF impacts.

## 2. Documentation

### *2.1 NEI 12-06, Rev. 2, Section G.2 – Characterization of the MSFHI*

The MSFHI to be evaluated in the MSA was determined in the Beaver Valley FHRR, Rev 0, and subsequently as Table 2 in NRC correspondence Letter ML17040A011, with Enclosure ML17039A550. This letter identifies the staff review and results of the audit of the FHRR, as well as any Request for Additional Information or supplemental data.

The LIP and CEF, including wind generated waves, exceed the current design basis.

***<u>Local Intense Precipitation (LIP)</u>***

**Flood Height**

The maximum water surface evaluation (WSE) slightly exceeds the current design basis. For Unit 1, the largest inundation depth above door elevations is 0.4 ft, which results in 8 doors being flooded. For Unit 2, the largest inundation depth above door elevations is 0.5 ft, which results in 4 doors being flooded. An evaluation concluded that, based on the flooding depth and duration, there is no impact to safety related equipment at 10 of the 12 doors. Due to the prolonged duration of the flood water, the final two doors were modified for flood mitigation (discussed under flood event duration).

Also, one flooded door is required to be open for FLEX activities. This requires that an additional flood protection barrier be installed on an adjacent door to prevent internal flooding.

**Flood Event Duration**
The flood duration above the door elevation is 15 minutes for most of the doors. However, several doors are inundated above the door elevation for up to 1.5 hours, and more than 6 hours at two door locations. Based on the results of the FHRR, the two doors flooded for 6 hours were modified with flood protection barriers.

**Relevant Associated Effects**
There are no associated effects related to a LIP event.
The calculated hydrostatic and hydrodynamic loads for all safety-related structures are significantly less than the design basis wind loads and loads produced from the design basis tornado.
Very little debris or sediment will be deposited based on the impermeable material surrounding the power block area, preventing debris and sediment being entrained in flood waters.
There are no specific concurrent site conditions identified during a LIP event.
The LIP event is a short duration event, and any combination of high winds and flooding would be short lived. Ice formation is not credible.
There will be no adverse groundwater surcharge effects due to the short duration of inundation and impermeable materials surrounding the power block area.

**Warning Time**
A LIP event provides limited warning time; therefore, the evaluation of the FLEX strategies was performed assuming the LIP event could occur at any point on the FLEX timeline. It was concluded that sufficient time margin exists to delay FLEX activities until LIP flood waters have receded. (Based on installation of a flood barrier on door 1-F-35-3, discussed later in section 2.3.2).

***Combined Effects Flooding, including wind wave effects (CEF)***

**Flood Height**
As described in the MSFHI letter, the design basis still water elevation (730.0 ft) is utilized in this assessment instead of the value submitted in the FHRR (727.53 ft). The overall CEF (with wind generated waves) values did not increase, as indicated in the MSFHI letter, due primarily to the extreme conservative assumptions and inputs used in the wind wave runup analysis for the FHRR.

The reevaluated CEF maximum design basis values are exceeded in three locations: 732.8 ft at the Unit 1 Turbine Building North wall, 734.0 ft at the ground slope approaching the Unit 2 Reactor Building, and 734.5 ft at the ground slope approaching the Emergency Outfall Structure (EOS). The wave runup at the Unit 2 Power Block (Reactor Building) and the EOS location is maintained on the ground slope approaching the structures and therefore does not impact the safety related structures.

Based on the overall building arrangement, the wave runup at Unit 1 Turbine Building will result in no wave action or wave energy affecting the internal Service Building flood barrier walls. Multiple obstructions would prevent the wave energy transfer including the Turbine Building north wall which is metal siding, numerous large diameter piping runs, heavy equipment located within the Turbine Building, and the reinforced concrete Turbine Building south wall. The Turbine Building south wall is adjacent to the Service Building north wall (flood barrier) with a 4 inch seismic shake space in between.

**Flood Event Duration**

The CEF event is slow developing and allows for appropriate preparations. For this discussion, the period of inundation begins once the Ohio River reaches 690 ft, and then recedes back to this value. This is an arbitrarily chosen value, which is 15 feet below the operating deck of the Intake Structure and lowest elevations of the power block area, and was chosen based on available design basis information. This results in approximately 100 hours of flooding on site. The FHRR USACE hydrographs for the basinwide PMF provides that the inundation lasts for about 74 hours for the 690 ft elevation. It should be noted that the site flood protection features are not specifically sensitive to any small difference of inundation timeframes.

**Relevant Associated Effects**

No significant debris is expected to be transported to the power block area based on the low velocities of the CEF event, and the multitude of obstacles, i.e. fence lines, non-safety related structures, and topographical features, around the power block area preventing debris transport. The power block and surrounding area are mostly macadam and concrete. Based on these hard materials and low velocities (< 10 ft/sec) of the flood waters, scour is not considered an issue. It is assumed that the CEF will result in some soil deposition at the site, however, it will not inhibit the safe operation of the station.

The specific additional effects identified during a CEF event, is the wind speed required to generate the wave effects during the site specific PMF. Although, the design basis wind speed value (40 mph) for creation of wind generated waves is exceeded by the new hazard wind speed (50 mph) it is bounded by the existing design basis wind speeds for the power block structures and the Intake structure (80 mph). The wave runup effects were discussed previously.

**Warning Time**

There is no specific warning time; however, the CEF event is slow developing and both units will be shutdown well in advance of the peak of the CEF. Based on existing abnormal operating procedures (AOP), initial actions occur when the river water level reaches 670 ft. The AOP directs a multitude of preparation activities, including mobilizing additional personnel to be onsite, and increases the monitoring time as the rivers rises. The duel unit plant shutdown will commence at 695 ft if flood predictions above 700 ft are indicated. Additionally, the existing severe weather AOP will be entered once sustained winds reach > 40 mph.

### *2.2 NEI 12-06, Rev. 2, Section G.3 – Comparison of the MSFHI and FLEX DB Flood*

The following tables provide the comparison of the plant design basis, FLEX design basis and the MSFHI for the various flood parameters, as applicable. The notes following the tables provide more explanation of each of the specific parameters listed in the tables.

Table 1: Local Intense Precipitation

Table 2: Combined Effects Flooding – which includes the effects of the PMF producing the maximum WSE of the Ohio river + wind generated wave action.

## Table 1 – Flood Causing Mechanism: Local Intense Precipitation

| | Flood Scenario Parameter<br>*(The attached notes provide further discussion for each corresponding numbered parameter listed)* | Plant Design Basis Flood | FLEX Design Basis Flood Hazard | MSFHI | MSFHI Bounded (B) or Not Bounded (NB) |
|---|---|---|---|---|---|
| Flood Level and Associated Effects | 1. Max Stillwater Elevation | BV Unit 1<br>Not identified<br><br>BV Unit 2<br>732.5 ft to 735.4 ft | BV Unit 1<br>Not identified<br><br>BV Unit 2<br>732.5 ft to 735.4 ft | Maximum BV Unit 1<br>735.9 ft<br><br>Maximum BV Unit 2<br>735.7 ft | NB |
| | 2. Max Wave Run-up Elevation | Not discussed in UFSAR | Not discussed in UFSAR | Minimal | B |
| | 3. Max Hydrodynamic/Debris Loading | Not discussed in UFSAR | Not discussed in UFSAR | Minimal | B |
| | 4. Effects of Sediment Deposition/Erosion | Not discussed in UFSAR | Not discussed in UFSAR | None | B |
| | 5. Other associated effects (identify each effect) | None | None | None | B |
| | 6. Concurrent Site Conditions | Not discussed in UFSAR | Not discussed in UFSAR | None | B |
| | 7. Effects on Groundwater | Level changes with Ohio River level changes | Level changes with Ohio River level changes | Minimal | B |
| Flood Event Duration | 8. Warning Time (hours) | Not discussed is UFSAR | Not discussed is UFSAR | Not required | NB |
| | 9. Period of Site Preparation (hours) | Not discussed in UFSAR | Not discussed in UFSAR | Not required | NB |
| | 10. Period of Inundation (hours) | One Door for > 1 | One Door for > 1 | Maximum >6 | NB |
| | 11. Period of Recession (hours) | Not discussed in UFSAR | Not discussed in UFSAR | Not required | NB |
| Other | 12. Plant Mode of Operations | Not discussed in UFSAR | Not discussed in UFSAR | Mode 1 - 6 | NB |
| | 13. Other Factors | None | None | None | B |

*All elevations are in NGVD29/ MSL unless otherwise noted.

| The notes below align with the data in the table numbering and provide any other relevant information for the table information. |
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| 1.<br>Since the LIP is not specifically discussed in the BVPS-1 UFSAR, and there are specific MSFHI values that are above the DB values at Unit 2, it is considered not bounded at both Units.<br><br>Ref. Calculation DSC-6794, FHRR Section 2.1.1 & 3.8, BVPS-1 UFSAR Section 2.3, BVPS-2 UFSAR Section 2.4.2.3.2 |
| 2.<br>There was no wave run up values associated with the MHFLI LIP. The event is short duration and the relatively shallow standing water recedes quickly. The UFSARs do not address wave run up associated with flooding from the LIP. Neither the design basis nor the MSFHI identified this as an issue. This item is bounded.<br><br>Ref. BVPS-1 UFSAR Section 2.3, BVPS-2 UFSAR Section 2.4.2.3.2, FHRR Section 3.8, NRC MSFHI Letter |
| 3.<br>No specific debris loading was discussed in the FHRR or provided in the LIP calculations related to load effects on power block structures. Hydrostatic and hydrodynamic loads on power block structures were calculated in the MSA report. The calculated loads for all safety-related structures are significantly less than the design basis wind loads and the design basis tornado (360 mph, 330 psf). No debris loads are anticipated. Due to the layout of the site, any entrained debris from the upper slopes will be captured by the various barriers, vehicle barrier system and fences, prior to impacting any structures. The buildup of debris would reduce the amount of flood water which could pass through these upstream barriers and enter the power block area. Waterborne debris impact loads would be significantly less than the design basis tornado wind driven missile loads, so there is no concern with these loads on safety-related structures.<br><br>Numerous non-safety related structures have calculated loading which exceeds design basis wind speed loading including the Unit 1 Aux Bay, Warehouse Extension, Unit 2 Turbine Building, Condensate Polishing Building and the South Office Shop Building. However, collapse or failure of the structures is not credible due to the loading produced by the LIP being based on the relatively shallow depths around the buildings. Additionally, the non-safety-related structures are not flood proof, and there would be equal buildup of pressure on each side the exterior walls effectively removing the hydrostatic loads. Flooding in these buildings would not affect any safety-related equipment as the elevations below the flood water heights do not communicate to safety related areas of the plant.<br><br>The LIP calculation is conservative - it assumes the site drainage system is not functional, all roof drains contribute to the LIP and that the Peggs Run PMF contributes to the LIP event. In actual practice, it is expected these systems will function minimizing the depth of the flood waters associated with a LIP event. Therefore, the hydraulic loads presented are highly conservative. Each of the buildings with loads greater than their design wind loading were reviewed in the associated notes of the MSA report. In each case the impact of the hydrodynamic/hydrostatic loads were determined to be inconsequential. Neither the design basis nor the MSFHI identified this as an issue, and the loadings are found to be inconsequential. This item is bounded.<br><br>Ref. Calculation DSC-6794, BVPS-1 UFSAR Section 2.7.1.2 & 2.7.2.3, BVPS-2 UFSAR Table 3.5-5, Enercon Report FNOCBV-060-REPT-001 |

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| 4.<br>Beaver Valley is located on terraced terrain. The average velocity of the flood waters during the LIP varies with the terrain. Some significant velocities exist in areas where the terrain drops significantly. These are localized areas, and none are directly adjacent to power block structures. Velocities in the power block areas are less than 5 ft/sec. Very little debris or sediment will be deposited based on the impermeable material surrounding the power block area, preventing debris and sediment being entrained in flood waters. This area is concrete and/or macadam. This hard material will also prevent scour, so it is not considered to be credible. Neither the design basis nor the MSFHI identified this as an issue, and it is not considered to be credible. This item is bounded.<br><br>Ref. BVPS-1 and BVPS-2 UFSAR Chapter 2, FHRR, Calculation DSC-6794, Enercon Report FNOCBV-060-REPT-001 |
| 5.<br>No additional associated effects were identified. Neither the design basis, nor the MSFHI identified any other detrimental effects. This item is bounded.<br><br>Ref. BVPS-1 and BVPS-2 UFSAR Chapter 2, FHRR |
| 6.<br>No specific concurrent site conditions have been identified during a LIP event. It is reasonable to assume there will be winds associated with the storm. However, the timeframe of the LIP event is a short duration event, and any combination of high winds and flooding would be short lived. Ice formation is not credible. Neither the design basis, nor the MSFHI identified any other concurrent site conditions. These values are marked bounded.<br><br>Ref. BVPS-1 and BVPS-2 UFSAR Chapter 2, FHRR, Calculation DSC-6794 |
| 7.<br>There will be no adverse groundwater surcharge effects. The short duration of inundation and impermeable materials surrounding the power block area would prevent any change in the groundwater elevation. Per the UFSAR, groundwater elevations equalize with Ohio River elevations. With the LIP being a small geographical event it is not expected to cause a significant increase in the Ohio River water level. This item is considered bounded.<br><br>Ref. BVPS-1 UFSAR Section 2.3.2.3, BVPS-2 UFSAR Section 2.5.4.10.2, FHRR |
| 8.<br>No specific warning time is identified in either the design basis or the MSFHI. AOP 75.1 Acts of Nature-Severe Weather contains guidance and reference to available weather information. In the event of a Severe Thunderstorm Warning for Beaver County the AOP is entered and actions are taken per Attachment 3 of the AOP. The AOP recognizes that time may be limited to perform the actions. There is no procedure directing action specifically related to flooding from a LIP event, and no actions are specifically needed to respond to a design basis LIP event. However, flooding impacts from the FHRR LIP event have been evaluated in Calculation DSC-0368, and permanent corrective actions taken to prevent significant impacts from the MSFHI LIP event. There is no specific need for warning time determined from review of the MSFHI LIP, as required actions would have already been performed procedurally prior to any forecasting of an LIP event.<br>Since the design basis does not discuss this issue and the MSFHI does, it is considered not bounded; however, there are no concerns associated with the warning time attribute of the LIP. |

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| Ref. FHRR, Calculation DSC-6794, Calculation DSC-0368, 1/2OM-53C.4A.75.1 Acts of Nature- Severe Weather (AOP 75.1) |
| 9.<br>As discussed in Note 8, site preparations for a severe thunderstorm, a potential precursor to a LIP event is contained in Attachment 3 of AOP 75.1. The resultant flood from a LIP event develops rapidly. A review of the flooding hydrographs in Calculation DSC-6794 indicates minimal preparation time will be available. The Site has already evaluated the LIP event effects as discussed in Note 8. In addition to the specific actions already taken as identified in Attachment 3, it is assumed, in general, that site personnel will close doors, hatches and other water ingress paths in the event of severe rainfall. Standard practice has personnel close exterior doors to safety-related areas of the plant. No preparations are required for the design basis or NRC Interim Staff Response (ISR) MSFHI LIP.<br><br>Since the design basis does not discuss this issue and the MSFHI does, it is considered not bounded; however, there are no concerns associated with the site preparation attribute of the LIP.<br><br>Ref. BVPS-1 and BVPS-2 UFSAR Chapter 2, FHRR, Calculation DSC-6794, Calculation DSC-0368, 1/2OM-53C.4A.75.1 Acts of Nature- Severe Weather (AOP 75.1) |
| 10.<br>The total site inundation period in the power block area is longer than 6 hours (length of storm) at various locations, however there is only a short duration of time above most critical plant door thresholds. Calculation DSC-0368 has determined all doors susceptible to water ingress during a LIP event result in no effect on safety-related SSC's, except for two doors. ECP 15-0357 installed permanent barriers at the two doors which removed the potential impacts. For most of the 6-hour timeframe depths and velocities around the site are inconsequential.<br><br>Inundation of the FLEX haul paths and staging areas will persist for greater than 6 hours due to low spots and ponding. Although there is still water above grade, the depths and velocity will allow Operators to access the equipment and connection points to support FLEX actions.<br><br>The UFSAR describes one door exceeded during the 1-hour LIP event. Since the design basis value is less than the MSFHI value, and other doors are exceeded, it is considered not bounded; however, there are no concerns associated with the period of inundation attribute of the LIP.<br><br>Ref. BVPS-1 and BVPS-2 UFSAR Chapter 2, FHRR, Calculation DSC-6794, Enercon Report FNOCBV-060-REPT-001, ECP 15-0357 |
| 11.<br>The period of recession is not significant for the LIP event at the site. Due to the topography and various depths around the site a recession time is not clearly definable for the MSFHI LIP. However, after 6 hours the rain event ends, and the water would quickly drain to the north due to the sloping topography of the site towards the Ohio River.<br><br>Calculation DSC-6794 provides that due to the assumption that a large drainage culvert is blocked, there is a flood potential at the alternate site access. As shown in the MSA report, the normal site access point will be impacted during a LIP due the hazardous conditions at point 2 and 9. A review of Enercon Report FNOCBV-060-REPT-001, shows velocities in the access area can be as high as 10 ft/sec with depths of 2 ft for brief periods of time. Due to the extreme sloped area to the north, once the rain has stopped or tapered the resultant flood depths and velocities will decrease allowing access for site personnel. It may also be possible |

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| to use the normal site access during the LIP using large vehicles with sufficient ground clearance and weight to traverse the flooded areas. If this is assumed, there is no LIP impact. Since the design basis does not discuss this and the MSFHI does, it is considered not bounded; however, there are no concerns associated with the period of recession attribute of the LIP.<br><br>Ref. BVPS-1 and BVPS-2 UFSAR Chapter 2, FHRR, Calculation DC-6794, Enercon Report FNOCBV-060-REPT-001 |
| 12.<br>Plant modes are not discussed in the UFSARs related to LIP flooding event. However, the design basis LIP does not impact the plants ability to shutdown or safely maintained shutdown. The FLEX strategy does identify different responses based on Plant mode and the availability of steam generators for heat transfer.<br><br>Since the design basis does not specifically discuss this and the MSFHI does, it is considered not bounded; however, there are no concerns associated with the plant modes of operations attribute of the LIP.<br><br>Ref. BVPS-1 and BVPS-2 UFSAR Chapter 2, FHRR |
| 13.<br>No additional factors were identified associated with the design basis or MSFHI LIP. Due to the absence of loose debris to be moved by the LIP flood waters inside the protected area, and the general low water depths around structures, waterborne projectiles are not considered credible. Since neither the design basis nor the MSFHI identified this as an issue, the other factors attribute is marked bounded.<br><br>Ref. BVPS-1 and BVPS-2 UFSAR Chapter 2, FHRR, Enercon Report FNOCBV-060-REPT-001 |

## Table 2 – Flood Causing Mechanism: CEF, Including Wind Generated Waves

| | Flood Scenario Parameter<br>*(The attached notes provide further discussion for each corresponding numbered parameter listed)* | Plant Design Basis Flood | FLEX Design Basis Flood Hazard | MSFHI | MSFHI Bounded (B) or Not Bounded (NB) |
|---|---|---|---|---|---|
| Flood Level and Associated Effects | 1. Max Stillwater Elevation | 730 ft | 730 ft | 730 ft | B |
| | 2. Max Wave Run-up Elevation | Intake Structure 736.7 ft | Intake Structure 736.7 ft | Intake Structure 734.0 ft | B |
| | | Unit 1 Turbine Building North Wall Not Protected | Unit 1 Turbine Building North Wall Not Protected | Unit 1 Turbine Building North Wall 732.8 ft | NB |
| | | Unit 1 Interior Wall (SB North Wall) 730 ft | Unit 1 Interior Wall (SB North Wall) 730 ft | Unit 1 Interior Wall (SB North Wall) 730.0 ft | B |
| | | Unit 2 Structures 730 ft | Unit 2 Structures 730 ft | Unit 2 Structures 734.0 ft | NB |
| | | EOS 730 ft | EOS 730 ft | EOS 734.5 ft | NB |
| | 3. Max Hydrodynamic/Debris Loading | Intake Structure 736.7 ft | Intake Structure 736.7 ft | Intake Structure 734.0 ft | B |
| | | Category 1 Structures | Category 1 Structures | Category 1 Structures 730.0 ft | B |
| | 4. Effects of Sediment Deposition/Erosion | Not discussed in UFSAR | Not discussed in UFSAR | Minimal | B |
| | 5. Other associated effects (identify each effect) | N/A | N/A | None | B |
| | 6. Concurrent Site Conditions | Wind Speed 40 mph | Wind Speed 40 mph | Wind Speed 50 mph | NB |
| | 7. Effects on Groundwater | 730 ft | 730 ft | 730 ft | B |

| Flood Scenario Parameter<br>*(The attached notes provide further discussion for each corresponding numbered parameter listed)* | | Plant Design Basis Flood | FLEX Design Basis Flood Hazard | MSFHI | MSFHI Bounded (B) or Not Bounded (NB) |
|---|---|---|---|---|---|
| Flood Event Duration | 8. Warning Time (hours) | >24 | >24 | >24 | B |
| | 9. Period of Site Preparation (hours) | Approx. 78 | Approx. 78 | Approx. 78 | B |
| | 10. Period of Inundation (hours) | Approx. 100 | Approx. 100 | Approx. 74 | B |
| | 11. Period of Recession (hours) | 70 | 70 | 30 | B |
| Other | 12. Plant Mode of Operations | Mode 1 - 6 | Mode 1 - 6 | Mode 1 - 6 | B |
| | 13. Other Factors | N/A | N/A | None | B |
| *All elevations are in NGVD29/ MSL unless otherwise noted. | | | | | |

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| The notes below align with the data in the table numbering and provide any other relevant information for the table information. |
| 1.<br>The NRC MSHFI letter provides the still water elevation to use in the MSA as 730 ft.<br>As the MSFHI still water elevation is the same as the DB, it is considered bounded.<br><br>References: NRC MSFHI Letter, BVPS-1 and BVPS-2 UFSAR Chapter 2 |
| 2.<br>BVPS-1 UFSAR Section 2.3.8.4 states, "The Intake Structure is the only safety-related structure which will be subjected to the effects of coincident waves and associated run up." From the NRC MSFHI letter the CEF on site grade is: 732.8 ft at the Unit 1 Turbine Building north wall, 734.0 ft at the ground slope approaching Unit 2 Reactor Building, and 734.5 ft at the ground slope approaching the Emergency Outfall Structure (EOS).<br><br>The CEF approaching the Unit 2 Power Block (Reactor Building) and the EOS location is maintained on the ground slope approaching the structures and therefore does not impact the safety related structures. However, it is above the design basis value and therefore is not bounded. The Intake Structure MSFHI CEF value is less than the DB value and is considered bounded. As the MSFHI CEF value is above the DB value for the Unit 1 Turbine Building north wall it is considered not bounded.<br><br>In the MSFHI letter, Beaver Valley agreed to use the DB still water elevation (SWE) for the MSA report instead of the values submitted in the FHRR. The overall CEF values did not increase as indicated in the MSFHI letter. This is due to the extreme conservative assumptions and inputs used in the wind wave runup analysis for the FHRR.<br><br>However, using the design basis still water elevation raises the SWE from that submitted in the BVPS FHRR. Due to the higher SWE, the conservatisms in the wind wave analysis have been reviewed with respect to the Unit 1 internal Service Building north wall (south of the Turbine Building). The internal wave swell estimated within the Unit 1 Turbine Building was determined to be an over conservative assumption in the FHRR and unrealistic based on site configuration. The following refinement is made to the wind wave analysis.<br><br>The north wall of the Unit 1 Turbine Building experiences an overall PMF SWE of 730.0 ft and wave runup of 2.8 ft per the MSFHI letter. Since the Turbine Building north wall is not a flood barrier the SWE on each side of the wall would be the same (730.0 ft); however, the wave energy would not be able to travel to the DB flood barrier wall at the Turbine Building/Service Building Interface. Multiple obstructions would prevent the wave energy transfer including the Turbine Building north wall, which is metal siding, numerous large diameter piping runs, heavy equipment located within the Turbine Building, and the reinforced concrete Turbine Building south wall. The Turbine Building south wall is adjacent to the Service Building north wall (flood barrier) with a 4-inch seismic shake space in between. Based on the overall arrangement, no wave action or wave energy can reasonably be considered to reach the internal Service Building flood barrier walls. The CEF SWE at the internal Service Building floor barrier walls is taken to be the SWE of 730.0 ft. The 730.0 ft is equal to and bounded by the existing UFSAR design basis.<br><br>Based on this discussion all CEF water surface elevations have no adverse impact to any safety-related SSC required for safe shutdown. |

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| Reference: Calculation DSC-6799, FHRR Section 2.1.4, 2.1.8, BVPS-2 UFSAR Section 2.4.3.6, BVPS-1 UFSAR Section 2.3.8.4 |
| 3.<br>No specific debris loading was provided in the CEF calculations related to the effects on power block structures. The CEF level impacts the Intake structure and the Unit 1 Turbine Building. The CEF at Unit 2 do not reach the power block structures. The intake structure CEF levels are bounded by the existing DB. The Unit 1 Turbine Building is not bounded; however, it is not designed to be flood proof during a PMF. As described in the design basis, the Unit 1 Turbine Building flooding above 725.5 ft will allow flooding of the Pipe Tunnel, which in turn allows flooding of the Auxiliary Building and a portion of the north Safeguards area. This flooding offsets the buoyancy effects on the buildings during a PMF. This flooding is described and bounded by the existing DB.<br><br>The site is rolling hill terrain with the power block structures located on a terrace. No significant debris is expected to be transported to the power block area based on the low velocities of the CEF event, and the multitude of obstacles, i.e. fence lines, non-safety related structures, and topographical features, around the power block area preventing debris transport. The Intake Structure is located next to the Ohio River and is more exposed to the flood waters than the power block structures. The safety related areas of the intake structure are designed to withstand the design basis tornado loading, 330 psf, on exterior walls and the full spectrum of tornado missiles. Additionally, the intake structure is design for the loading produced by the equal design basis flood of 730.0 ft.<br><br>The values are at or below the DB by comparison and qualitative evaluation and is therefore bounded.<br><br>Reference: Calculation DSC-6799, FHRR 3.7.4, BVPS-1 UFSAR Section 2.3.3, 2.7.3.2.5, 2.7.11, 2.3.8.4, 2.3.3, 2.3.8.4, 9.7.1, 9.7.3, 9.7.4, 9.7, 14.1.14.2 |
| 4.<br>The site is rolling hill terrain with the power block structures located on a terrace. The power block and surrounding area are mostly macadam and concrete. Based on these hard materials and low velocities (< 10 ft/sec) of the flood waters scour is not considered an issue. The actual estimated velocity of the flood water on the river banks during a PMF is 3 mph or 4.4 ft/sec.<br><br>It is assumed that the CEF will result in some soil deposition at the site, and potentially internal to the Turbine Building. As the additional areas flooded during this event, discussed in Note 3, are within the existing DB, soil deposition, should it occur will not inhibit the safe operation of the station, as these areas are not designed to be protected from flooding in a PMF. The CEF waters do not reach the Unit 2 Power Block structures, and therefore scour is not a concern.<br><br>The Intake Structure is surrounded by flood waters during the DB and MSFHI CEF. The Intake Structure is supported on bedrock. Therefore, scouring is not a concern. The sands and gravels of the lower terrace over which the river intake lines pass have been recompacted to median relative densities exceeding 75 percent along the route of these pipe lines. Therefore, this is not a hazard.<br><br>In the CEF scenario, the plant is required to shutdown and cooldown in advance of the rising flood waters. Based on flood levels and wind speeds in the CEF scenario it is expected most make up tanks will remain viable and preclude the need for long term river water usage.<br><br>Since the UFSAR and DB do not discuss this issue and the MSFHI is minimal, it is considered bounded. |

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| References: Calculation DSC-6799, FHRR 3.7.4, BVPS-1 UFSAR Chapter 2, Appendix 2H, Attachment 2.3A, Figure 16, AOP 75.2 Acts of Nature -Flood |
| 5.<br>No additional associated effects were identified.<br><br>Since the UFSAR and DB do not discuss this issue and the MSFHI did not identify any additional effects, it is considered bounded.<br><br>Reference: Calculation DSC-6799, FHRR 3.7.4, BVPS-1 UFSAR Chapter 2, BVPS-2 UFSAR Chapter 2 |
| 6.<br>The specific additional effects identified during a CEF event, is the wind speed required to generate the wave effects during the site specific PMF. The power block area and structures below elevation 730.0 ft are affected by the CEF. The wind generated waves associated with the CEF increase the flood height around the power block and the intake structure. The only affected power block structure is the Unit 1 Turbine Building. This building is designed to flood and flooding commences well below 730.0 ft by design. Other power block structures flooded during this event, discussed in Note 3, are unaffected by wind generated waves. No other power block structures for either unit are affected by wind generated waves, as the waves break on the slopes approaching these buildings. This includes all other Unit 1 buildings, Unit 2, the FLEX Equipment Storage Building (FESB) and the emergency outfall system (EOS). The CEF wave height at the intake structure is bounded by the DB.<br><br>The wind speed assumed to generate the waves is the 2-year max sustained windspeed of 50 mph per ANS-2.8-1992. The existing DB wind generated wave wind velocity is a sustained wind of 40 mph for approximately 2 hours. The new hazard wind speed is slightly larger than the DB value but the overall wind speed is not excessively large being the 2-year occurrence interval. The value is bounded by the existing design basis wind speeds for the power block structures and the Intake structure. An 80-mph fastest mile wind speed, at an assumed elevation of 30 feet, is used as the design wind velocity to determine wind loadings on Seismic Category I structures. Since the DB wind speed value (40 mph) for creation of wind generated waves is less than the new hazard wind speed (50 mph) it is considered not bounded. However, no negative impact to Category 1 and non-Category 1 structures is anticipated based on this wind speed. Also, AOP 1/2.75.1- Acts of Nature Severe Weather will be entered once the sustained winds reach > 40 mph. No specific actions related to this event are given or are warranted. Post High Wind event actions are contained in the procedure.<br><br>References: Calculation DSC-6799, BVPS-1 UFSAR section 2.3.8, 2.3.8.1, 2.3.8.3, 2.3.8.4, ANS-2.8-1992 |
| 7.<br>The groundwater at the site is typically below all structure base mats except for structures located at the river's edge. Groundwater at the site typically is equivalent to the Ohio River surface elevation. During a CEF event the Ohio River will rise to a height of 730.0 ft. Therefore, the groundwater will rise accordingly causing a groundwater surcharge. The site flood protected structures are designed for a PMF of 730 ft including the resultant groundwater hydrostatic pressures. The wave action will cause a small increase in this pressure; however, except for the Unit 1 Turbine Building and the Intake structure, no other buildings are subject to this increase, as they are not subject to wave action. Ground water would not be subjected to the wind wave energy and would not raise above the 730.0 ft still water elevation. The remaining Category 1 power block structures are designed for flood levels up to 730 ft including the resultant groundwater hydrostatic pressures. Therefore, it is bounded. |

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| References: References: Calculation DSC-6799, BVPS-1 UFSAR Section 2.3.2.3, 2.3.2.1.2, 5.2.2.5.1, BVPS-2 UFSAR Section 3.4, 2.5.4.6, 2.4.13.5 |
| 8.<br>The UFSAR discusses the PMF as well as the potential for wind generated waves. The UFSAR states that the station will act as the water level rises to and including normal shutdown and cooldown. The License Requirements Manual requires this action at 700 ft elevation in the Ohio River.<br><br>The site will enter AOP 1/2.75.2 - Acts of Nature Flood at 670 ft. This AOP directs a multitude of preparation activities, including mobilizing additional personnel to be onsite, and increases the monitoring time as the rivers rises. The duel unit plant shutdown will commence at 695 ft if flood predictions above 700 ft are indicated. The CEF event is slow developing event and the units will be shutdown well in advance of the peak of the CEF.<br><br>Due to the magnitude of the storm required to produce the PMF site personnel would be aware of the impeding flood before the river level begins to rise. Both the UFSAR design basis Attachment 2.3-A, Plate 4 and the FHRR USACE hydrographs for the basinwide PMF provide approximately 3.25 days of warning and preparation time from inception of the rainfall onto the watershed to the peak flood elevation. Similar timeframes would be expected to exist for the NRC MSFHI letter flood values. AOP 1/2.75.1- Acts of Nature Severe Weather will be entered once the sustained winds reach > 40 mph. No specific actions related to this event are given or are warranted. Post High Wind event actions are contained in the procedure.<br><br>Based on the above and the slow development of the event, this item is considered bounded.<br><br>References: Calculation DSC-6799, FHRR Section 4- Table 3, AOP 75.1 and 75.2, BVPS-1 UFSAR Section 2.3.3, Attachment 2.3-A, Plate 4, Plate 5, BVPS-2 UFSAR Section 10.4.5.3, 2.4.15, 2.4.10, 2.4.3.6, 2.4.13.5, 2.4.14, Figure 2.4-7, Appendix 2.4A, USACE Hydrographs, License Requirements Manual Basis B 3.7.2 |
| 9.<br>Site Preparation is discussed in Note 8. The Flood AOP contains a significant number of actions based on various water level elevations in the Ohio River. As examples these include closing and sealing the flood doors at the intake structure, closing doors, hatches, staging pumps etc., as well as calling in additional staff. As discussed in note 10, the period of site inundation begins once the Ohio River reaches 690 ft. This results in approximately 78 hours of site preparation time prior to the River reaching 690 ft. No additional actions are identified for the NRC MSFHI letter values.<br><br>This item is considered bounded based on the discussions in Note 8.<br><br>References: Calculation DSC-6799, FHRR Section 4- Table 3, AOP ½ 75.1 and 75.2, BVPS-1 UFSAR Attachment 2.3-A, Plate 4, Plate 5, BVPS-2 UFSAR Section 10.4.5.3, 2.4.15, 2.4.10, 2.4.3.6, 2.4.13.5, 2.4.14, Figure 2.4-7, Appendix 2.4A, USACE Hydrographs |
| 10.<br>As discussed in the previous notes this event is slow developing and allows for appropriate preparations. For this discussion, the period of inundation begins once the Ohio River reaches 690 ft, and then recedes back to this value. This is an arbitrarily chosen value, which is 15 feet below the operating deck of the Intake Structure and lowest elevations of the power block area, and was chosen based on available design basis information. This results in approximately 100 hours of flooding on site per BVPS-1 UFSAR Attachment 2.3A Plate 5. The FHRR USACE hydrographs for the basinwide PMF |

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| provides that the inundation lasts for about 74 hours above the 690 ft elevation. The site flood protection features are not specifically sensitive to any small difference of inundation times. Similar timeframes would be expected to exist for the NRC MSFHI letter flood values. Based on this, the inundation period is considered bounded.<br><br>References: Calculation DSC-6799, FHRR Section 4 - Table 3, AOP 75.1 and 75.2, BVPS-1 UFSAR Attachment 2.3A Plate 4, Plate 5, BVPS-2 UFSAR Figure 2.4-7, USACE Hydrographs |
| 11.<br>The BVPS-1 UFSAR, Attachment 2.3A Plate 2 and 4, shows approximately 70 hours for recession from the peak PMF elevation of 730 ft to approximately 690 ft. The bulk of the site, and the power block area is only flooded for approximately 60 hours and the wave action only controls the overall peak near the peak of the still water flood. The FHRR USACE hydrographs for the basin-wide PMF shows that the peak PMF elevation at 690 ft lasts for approximately 30 hours. This is considerably shorter, and therefore this is considered bounded.<br><br>References: Calculation DSC-6799, BVPS-1 UFSAR Section 2.3.3, Attachment 2.3A Plate 2, 4, BVPS-2 UFSAR Figure 2.4-7 |
| 12.<br>Plant modes are discussed in the UFSAR related to flooding events. As the flood water elevation increases various actions are taken up to and including mode change to cold shutdown. The MSFHI does not directly address plant modes nor does the FHRR. As the PMF associated with CEF would require actions as discussed in Note 8, plant mode is considered bounded.<br><br>References: Calculation DSC-6799, BVPS-2 UFSAR Section 2.4.14, License Requirements Manual Basis B 3.7.2, USACE Hydrographs, Figure 16, FHRR |
| 13.<br>No additional factors were identified associated with the CEF. Since neither the design basis nor the MSFHI identified any additional factors, this is considered bounded.<br><br>References: Calculation DSC-6799, FHRR, BVPS–1 and BVPS-2 UFSAR Chapters 2 and 3 |

### *2.3 NEI 12-06, Rev. 2, Section G.4 – Evaluation of Mitigating Strategies for the MSFHI*

#### *2.3.1.NEI 12-06, Rev. 2, Section G.4.1 – Assessment of Current FLEX Strategies*

The overall plant FLEX response strategies to an ELAP or LUHS event can be implemented as described in the Final Implementation Plan using current procedures, equipment and personnel, pending the completion of the flood hazard mitigation modification (discussed below).

***2.3.1.1 Conclusion –*** *Modify FLEX*

#### *2.3.2 NEI 12-06, Rev. 2, Section G.4.2 – Assessment for Modifying FLEX Strategies*

The assessment concluded that the flood causing mechanisms would not initiate an ELAP or LUHS event, with the completion of a minor flood hazards mitigation modification. FLEX activities would be initiated through existing plant procedures for abnormal or emergency event response. The individual flooding mechanisms were evaluated assuming they could occur at any point on the FLEX strategy timeline to ensure that the most severe flooding would be evaluated at a time, which would have the most adverse impact on FLEX implementation. The assessment included evaluation of FLEX equipment storage areas, operations and staging locations, deployment travel paths, and the working conditions for personnel and equipment in flooded areas.

The assessment concluded that the MSFHI would not prevent FLEX implementation for the CEF event. The maximum reevaluated still water surface elevation of the Ohio River was determined to be 730.0 ft, which is equal to the current design basis. Wind generated wave runup at various locations exceeds the current design basis value:

- 732.8 ft at the Unit 1 Turbine Building North wall.
- 734.0 ft at the ground slope approaching Unit 2 Reactor Building.
- 734.5 ft at the ground slope approaching the Emergency Outfall Structure (EOS).

The Unit 1 Turbine Building will flood (per design); however, there will be no wave effects on the adjacent flood barrier (Service Building north wall). The WSE will be within the design basis value of 730.0 ft. The wave action approaching the Unit 2 Power Block (Reactor Building) and the Emergency Outfall Structure location is maintained on the ground slopes approaching the structures and therefore has no impact on the safety related structures. The assessment concluded that the FLEX strategies include sufficient margin and flexibility such that successful implementation is achievable with the increased flooding in the various areas.

For the LIP event, the assessment concluded that the MSFHI could potentially affect FLEX strategies due to flooding of internal Unit 1 areas when opening a door to support FLEX spent fuel pool activities. Installing a flood barrier will mitigate the adverse effects. All other FLEX strategies include sufficient margin and flexibility such that successful implementation is achievable with the increased flooding.

The actions identified below are required to mitigate the effects of the beyond design basis flood event assuring there will be no adverse effects on FLEX strategy implementation.

a. To mitigate the potential LIP flooding, install a removable flood barrier on door 1-F-35-3 (Engineering Change Package 15-357-003).

b. Revise, as required, FLEX Support Guidelines and Attachments for Unit 1 FLEX implementation to identify the requirement for barrier installation on door 1-F-35-3 when door 1-F-35-2 is opened for FLEX implementation.

The actions identified above will be tracked in the site corrective action program (Condition Report 2017-09202).

#### *2.3.2.1 Conclusion*

The MSA demonstrated that with the installation of a new flood protection feature, the FLEX strategies, as described in the FIP, are acceptable.

- The boundary conditions and assumptions of the initial FLEX design are maintained.
- The sequence of events for the FLEX strategies is not affected by the impacts of the MSFHI (including impacts due to the environmental conditions created by the MSFHI) in such a way that the FLEX strategies cannot be implemented as currently developed.
- The validation performed for the deployment of the FLEX strategies is not affected by the impacts of the MSFHI.
- The deployment locations of FLEX equipment are shown to be acceptable.
- There are no new or modified actions required for the FLEX strategies, except for identifying the potential installation of a door flood barrier.
- The flood protection features meet all performance criteria specified.

### *2.4 References*


- FHRR, Rev. 0, 2/4/2016 – 10 CFR 50.54(f), Regarding the Flooding Aspects of Recommendation 2.1 of the Near-Term Task Force (NTTF) Review of Insights from the Fukushima Dai-ichi Accident.
- NRC correspondence Letter ML 17040A011, with Enclosure ML 17039A550 – Dated 2/22/2017, Beaver Valley Power Station, Units 1 and 2 - Interim Staff Response To Reevaluated Flood Hazards Submitted In Response To 10CFR50.54(f) Information Request - Flood Causing Mechanism Reevaluation.
- NORM-LP-7121, Beaver Valley Power Station Flooding Mitigating Strategy Assessment Support Document.
- Beaver Valley Power Station BVPS-1 UFSAR Rev. 29
- Beaver Valley Power Station BVPS-2 UFSAR Rev. 22
- Calculation DSC-6794 Effects of Local Intense Precipitation Analysis
- Calculation DSC-6799 Coincident Wind Wave Analysis
- Enercon Report FNOCBV-060-REPT-001
- Calculation DSC-0368 BDB LIP Internal Effects Analysis
- Drawing RE-37A, Sleeves and Openings
- 1/2OM-53C.4A.75.1 Acts of Nature- Severe Weather (AOP 75.1)
- 1/2 OM-53C.4A.75.2 Acts of Nature Flood (AOP 75.2)
- License Requirements Manual Basis B 3.7.2, Flood Protection
- Condition Report 2017-09202, Flooding Mitigating Strategy Identified One Area of Concern with the FLEX Strategy