Working Example Template:

Scenario Based Integrated Assessment Evaluation of a "Sunny Day" Dam Failure with Advance Warning of an External Flood and Severe Site Flooding

Electric Generating Plant Unit 1

June 13, 2014

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Acronyms and Abbreviations

AC	Alternating Current
ADV	Atmospheric Dump Valve
AFW	Auxiliary Feed Water
AIA	Assigned Interface Agreement
AMP	Ampere
AOP	Abnormal Operating Procedure
ASCE	American Society of Civil Engineers
AWG	American Wire Gauge
CFR	Code of Federal Regulation
CLB	Current Licensing Basis
CST	Condensate Storage Tank
DC	Direct Current
EDG	Emergency Diesel Generator
EE	Engineering Evaluation
EPP	Emergency Preparedness Procedure
EOP	Emergency Operating Procedure
ERO	Emergency Response Organization
ES	End State
Fig.	Figure
FHRR	Flooding Hazard Reevaluation Report
FOT	Fuel Oil Tank
FRP	Flood Recovery Procedure
ft.	feet
FW	Feed Water
gpm	gallons per minute
HRA	Human Reliability Analysis
HVAC	Heating Ventilation and Air Conditioning
IA	Integrated Assessment
ID	Identification
IEEE	Institute of Electrical and Electronic Engineers
Inst.	Instrument
ISG	Interim Staff Guidance
KSF	Key Safety Function
Kva	kilovolt amperes
MAE	Manual Action Evaluation
MST	Maintenance Surveillance Test
Mwt	Megawatts Thermal
MCC	Motor Control Center
MCR	Main Control Room
MSSV	Main Steam Safety Valve
NAVD88	North American Vertical Datum of 1988
NPP	Nuclear Power Plant
NPRDS	Nuclear Plant Record Data System
NTTF	Near-Term Task Force

OA	Operator Actions
P	Pump
PF	Pre Flood
PMF	Probable Maximum Flood
PRA	Probability Risk Assessment
PFRP	Post Flood Recovery Plan
PSF	Performance Shaping Factor
PWR	Pressurized Water Reactor
QA	Quality Assurance
RCS	Reactor Coolant System
RRC	Regional Response Center
RWST	Refueling Water Storage Tank
SBO	Station Black Out
SDC	Severe Core Damage
SFMS	Severe Flooding Mitigation System
SFMS DG	Severe Flooding Mitigation System Diesel Generators
SFP	Spent Fuel Pool
SG	Steam Generator
SMF	Safety Margin Factor
SRO	Senior Reactor Operator
SSC	System, Structures and Components
TDAFW	Turbine Driven Auxiliary Feed Water
MCR	Technical Support Center
USACE	United States Army Corp of Engineers
v	Volt
Vac	volts ac
Vdc	volts dc
WSE	Water Surface Elevation
XF	External Flood

Preface

JDL-ISG-2012-05, "Guidance for Performing an Integrated Assessment for External Flooding" [ML12311A214, November 30, 2012] (Reference 1), provides a description of methods acceptable to the staff of the U.S. Nuclear Regulatory Commission (NRC) for performing the integrated assessment for external flooding as described in NRC's request for information, U.S. Regulatory Commission, 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, March 12, 2012 [ML12053A340](Reference 2) issued pursuant to Title 10 of the Code of Federal Regulations (10 CFR), Section 50.54, "Conditions of licenses," regarding Recommendation 2.1 of the enclosure to SECY-11-0093, "Recommendations for Enhancing Reactor Safety in the 21st Century, the Near-Term Task Force (NTTF) Review of Insights from the Fukushima Dai-Ichi Accident" (Reference 3). As discussed in the Interim Staff Guidance (ISG) the purpose of the integrated assessment is to: (1) evaluate the effectiveness of the current licensing basis under the reevaluated flood hazard, (2) identify plant-specific vulnerabilities due to external flood hazards, and (3) assess the effectiveness of existing or planned plant systems and procedures in protecting against flood conditions and mitigating consequences for the entire duration of a flooding event. As discussed the integrated assessment consists of: (1) an assessment of the plant's flood protection features and procedures (see section 6 of the ISG), and, if adequate margin is not available to demonstrate a highly reliable flood protection capability, (2) an assessment of flood mitigation capability (see Section 7 of the ISG). Should an assessment of mitigation capability be required Section 7 of the ISG provides three options to the Utility. These options are: (a)the scenario-based approach is intended to be a systematic, rigorous, and conservative, (although primarily qualitative) evaluation used to demonstrate that there is high confidence that key safety functions can be maintained, (b) a margins-type evaluation is quantitative and uses conditional core damage probability (CCDP) and conditional large early release probability (CLERP) as figures of merit or (c) establish the overall external flood core damage and large early release frequencies through the use of a plant specific external flood PRA.

The purpose of this paper is to illustrate by example Step 4 of Figure 2 in JLD-ISG-2012-05, the key elements of evaluation of site/plant external flood mitigation capability as part of an Integrated Assessment using a scenario based approach as described in Section 7.2. While the NRC offers three options for performing a mitigation capability assessment, the scenario based approach is expected to be applicable to many mitigation evaluations performed as part of integrated assessment evaluations. Note, that as stated in JDL-ISG-2012-05, "the licensee is responsible for justifying that the scenario-based evaluation provides sufficient detail and supporting information (e.g., captures dependencies, interactions, and total flood effect) to demonstrate that there is high confidence that key safety functions can be maintained." The purpose of this example is to illustrate an application of the Integrated Assessment Scenario based approach with a credible example as shown in Figure 4 of Reference 1.

This example treats a single external flood scenario based on a "sunny day" failure of a hypothetical upstream dam located 200 miles from the fictitious site of a 3000 Mwt. 4-Loop PWR. The nuclear plant is a single unit site. As the treatment is illustrative, it is necessarily incomplete. Where appropriate, the example includes preparer's notes to provide guidance as to the type and detail of the information that may be expected in explaining the scenario. Note that the number, type and complexity of scenarios required to support a plant specific integrated assessment will vary.

In using the example the following should be noted:

The example discussion illustrates an external flood mitigation capability evaluation using the scenario-based approach outlined in Reference 1. The identification of controlling flood mechanisms and the evaluation of external flood protection are only discussed to the extent necessary to define the scope and boundary conditions of the mitigation capability evaluation. A discussion for the basis for selection of the flood mechanism to be evaluated will be required in the Integrated Assessment submittal.

The example focuses on an evaluation of external flood mitigation capabilities of the plant/site. Detailed discussion of the external flood protective barriers and procedures (not directly related to the mitigation activity) is not included in this illustration. Information regarding external flood protection would also need to be included to the extent appropriate to meet the intent of the integrated assessment.

As this example focuses on a single unit site, issues regarding equipment sharing, equipment and resource availability and effectiveness of human actions that may be relevant for multi-unit sites are not directly addressed.

Strategies included in this example do not necessarily represent NRC-endorsed mitigation strategies or actions for a particular event but rather focuses on the level of detail required to describe and justify the adequacy of a proposed external flood mitigation strategy. Justification, assumptions, etc. used in this example are provided for illustrative purposes and do not necessarily represent justification, assumptions, etc. that would be appropriate/acceptable to NRC staff in an actual submittal or under specific site conditions.

Normal plant procedures used in response to the flood event (e.g., plant shutdown) and that are routinely trained upon will be identified as being invoked but not discussed in detail unless the conditions under which they are performed have changed. Flood specific procedures developed to prepare for, mitigate or maintain, test or surveillance equipment in advance of a flood hazard will be discussed to the extent necessary to identify the procedure and the key attributes of that procedure.

This flood scenario is presented only as a representative example of one flood scenario resulting from a "sunny day" failure of an upstream dam Plant's may have multiple flood mechanisms that may require an integrated assessment. The other mechanisms may be treated separately in other scenarios or enveloped by one or more evaluated scenarios.

The focus of the scenario example is on illustrating or describing the type of information and level of detail appropriate for documenting scenario –based mitigation evaluation demonstrating that there is high confidence that key plant safety functions are maintained throughout that flood event duration scenario. For illustration purposes, the example scenario presented does not include consideration of Spent Fuel Pool (SFP) cooling. A complete scenario description would be expected to also successfully disposition make-up to the SFP. Utilities are cautioned that events and mitigating conditions unique to their respective site may warrant consideration of additional plant safety functions and/or different responses.

The structure of this document uses running text to provide illustrative examples of the example write-up and "Preparer's Note" in italics to highlight the intent of the key sections and provide guidance as to additional or alternate information that may be required to supplement scenario descriptions.

As a general note, it is suggested that the preparer provide frequent references to the sections of the JLD-ISG 2012-05, as applicable. Also, references should be used for data or statements taken from the Flooding Hazard Reevaluation Report (FHRR).

1.0 Overview

The 50.54(f) letter (Reference 1) requested licensees and holders of construction permits under 10 CFR Part 50 to reevaluate the flooding hazards at their sites against present-day regulatory guidance and methodologies being used for early site permits and combined license review, and identify any interim actions taken or planned to mitigate the impact of flood hazards in excess of the plant design basis. In addition the NRC also requested those plants where the current design basis floods do not bound the reevaluated hazard for all flood causing mechanisms to provide an Integrated Assessment (IA) describing "the controlling flood mechanisms and its effects, and how the available or planned measures will provide effective protection and mitigation." Results of the hazard reevaluation are presented in Reference 4. That report (FHRR), noted that the site predicted maximum hazard flood elevation has increased 5 feet from 900 ft. 905 ft. (NAVD88). No other changes in the plant flood hazards were identified. Interim strategies to address the increased hazard have been implemented and are discussed in Reference 4.

This report provides the Integrated Assessment requested by Reference 1. For performing an integrated assessment of this flood elevation increase, the following specific characteristics of the external flood hazard were identified:

- Flood height and associated effects
- Warning time (time available from event notification to the time flood waters arrive on site)
- Intermediate water surface elevations that trigger actions by plant personnel
- Flood duration (Determined by hazard re-evaluation to be time between event notification and time flood waters recede from site. Note that this definition is separate from the IA definition of flood event duration which includes the additional time for ensuring Reactor Coolant System (RCS) is in a safe stable state).
- Other hazards associated with the scenario including debris and hydrostatic/hydrodynamic loading challenges and concurrent adverse weather conditions.
- Plant mode(s) of operation during the flood duration

This overall integrated assessment scenario-based evaluation discussion is organized as follows:

Section 2, provides a detailed discussion of the full scenario including important features of the hazard under evaluation and site elevations. Section 3 includes an overview of the plant's flood mitigation features and detailed description of the Severe Flood Mitigation System (SFMS). Section 4 provides the justification for determining the SFMS equipment reliable and documents the system's dependencies. Section 5 includes a timeline of the scenario and resources required to implement the mitigation strategy. Both a tabular and graphical presentation has been provided.

Section 6 discusses the Key Safety Functions (KSFs) that are required to be maintained throughout the entire flood event duration. A success path and an event tree have been included to illustrate the critical actions and equipment required to maintain the KSFs. Section 7 provides a human reliability assessment and analyses the feasibility and reliability of critical flood mitigation actions. A discussion of available margin and uncertainty associated with the human reliability assessment is provided in Section 8. Section 9 provides a conclusion. Section 10 provides references used in this example.

2.0 Description of the Flood Scenario and Initial Conditions

-- Preparer's Note --

This example focuses on a plant with a single controlling flood hazard. However, sites that have a diversity of flood hazards, should define multiple sets of flood scenario parameters to capture plant effects for each hazard. In addition, sites may use different flood protection systems to protect or mitigate against different flood hazards. In such instances, the integrated assessment should define multiple sets of flood scenario parameters. Section 5.2 of Reference 1 notes that it is acceptable to develop an enveloping scenario (e.g., the maximum water surface elevation and inundation duration with the minimum warning time generated from different hazard scenarios) instead of considering multiple sets of flood scenario parameters as part of the integrated assessment. For simplicity, the licensee may combine these flood parameters to generate a single bounding set of flood scenario parameters for use in the integrated assessment.

This section provides a complete picture of the flood scenario being analyzed in order to put in context the details of the integrated assessment for the scenario in question. This section includes a description of the hazard(s), key features of the site and surrounding area that may impact the response of the plant to the hazard and expected plant initial conditions at the time of the onset of the hazard. The scenario description begins at the time of dam breach and includes considerations of actions taken by the dam operator from the point of incipient dam breach to the notification of the onset of the flood event through the point the plant is restored to a safe stable state. The details of the hazard is as presented in the flooding hazard reevaluation report as requested in the 10CFR50.54(f) letter (Reference 2).

2.1 Scenario Selection

A review of the results of the hazard re-evaluation for all flooding mechanisms applicable to the site indicates that the only flooding mechanism that resulted in an adverse change in a flooding parameter (e.g., decreased warning time, or increased flood level) or required consideration of a previously unevaluated flood feature (e.g., debris considerations) involved the "sunny day" failure of a dam upstream of the site. The specific change that triggered the scenario selection was the re-analysis of the sunny day dam failure which resulted in an increase in the Probable Maximum Flood (PMF) from 900 ft. (NAVD88)[1] to 905 ft (NAVD88). Table 2-1 provides a comparison of hydrologic parameters and key modeling assumptions between the Current Licensing Basis (CLB) and the re-evaluated hazard.

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1 All elevations are provided based on the North American Vertical Datum of 1988

2.2 Flood Characterization

The plant has an external flood protection system that is based on a design basis flood of 900 ft (NAVD88). Site grade is 895 ft. The results of the re-evaluated hazard height indicate that a "sunny day" failure of an upstream dam would create a flood with a maximum WSE of 905 ft. A flood elevation in excess of 900 ft. will result in all CLB flood protection barriers at the site being overtopped resulting in a loss of core cooling and inventory control safety functions. The anticipated time for the flood (including consideration of wave run up) to reach plant grade (895ft) is 24 hours after initial dam breach. The top of flood barriers (900 ft.) may be reached as early as 30 hours after the initial dam breach. The peak flood height (905 ft.) can potentially be reached 36 hours after initial dam breach. This flood height is expected to remain near the peak elevation for a period of 10.5 days. After that time the flood is predicted to gradually subside until the water has receded below plant grade after 2.5 days. The scenario is terminated when the plant is placed in a long term stable condition such that there is high confidence that the all key plant and safety functions can be met indefinitely (See Section 2.5).

Figure 2-1 illustrates the expected transient behavior of the river level for the flood event duration. Reference 4 defines flood event duration as the length of time in which the flood event affects the site, beginning with conditions being met for entry into a flood procedure or notification of an impending flood including preparation for the flood and the period of inundation, and ending when water has receded from the site and the plant has reached a safe and stable state that can be maintained indefinitely. The time interval from the time of dam failure to the time flood waters recede from the site is defined as the flood duration.

Figure 2-1 for the "sunny day" dam failure initiates at the time the site receives notification of an impending flood and lasts until flood waters recede from site. Table 2-2 provides a tabular record of critical elevations and action points for the scenario. Note that in judging plant actions, the site is entirely "dry" for first the 24 hours of the event and all SSCs are functional up until the flood reaches 900 ft. (NAVD88) (thirty hours into the event). As discussed in Section 3, associated resupply routes are available to ensure an indefinite period of plant operation.

Table 2-1
Re-Evaluated Hazard Definitions (Section 5 of IA)
"Sunny Day" Failure of Upstream Dam

Parameter/Feature	Re-Evaluated Hazard Condition	Current Licensing Basis	Comment
Scenario Type	Sunny Day Dam Failure	Sunny Day Dam Failure	Selected for Integrated assessment as re-evaluated hazard exceeds a design basis flood parameter or did not consider a relevant flood parameter in the design basis
Plant Initial Condition at time of Flood	Shutdown	Shutdown	All equipment considered operable prior to onset of flood
Site grade	895 ft.	895 ft.	FSAR Section 2.0 (Reference 5)
Initial River Level at site	890 ft.	890 ft.	See Reference 4
Probable Maximum Flood	905 ft.	900 ft.	Re-evaluated hazard PMF exceeds CLB by 5 feet
Warning Time	24 hours prior to flood reaching site grade 30 hours for flood to overtop flood barriers	24 hours prior to flood reaching site grade. Flood barriers not overtopped	Flood barriers designed to CLB PMF. Warning time includes time for dam operators to notify site. This time interval is considered in evaluating site actions.
Flood Elevation Profile	See Figure 2-1	Flood barriers evaluated at CLB PMF (900 ft.)	
Flood Duration	14.5 days	Unspecified	
Wind waves and run-up effects	Included in flood elevations estimates	Included in flood elevations estimates	See Section 2.3
Debris Effects	No significant debris loading predicted on credited protection or mitigation features	Considered in CLB consistent with CLB PMF	See Section 2.3
Hydrodynamic/hydrostatic loading	No significant hydrodynamic/hydrostatic loading predicted on credited protection or mitigation features	Considered in CLB consistent with CLB PMF	See Section 2.3
Sedimentation	No significant sedimentation predicted	Considered in CLB consistent with CLB PMF	See Section 2.3
Erosion	No significant erosion predicted.	Considered in CLB consistent with CLB PMF	See Section 2.3

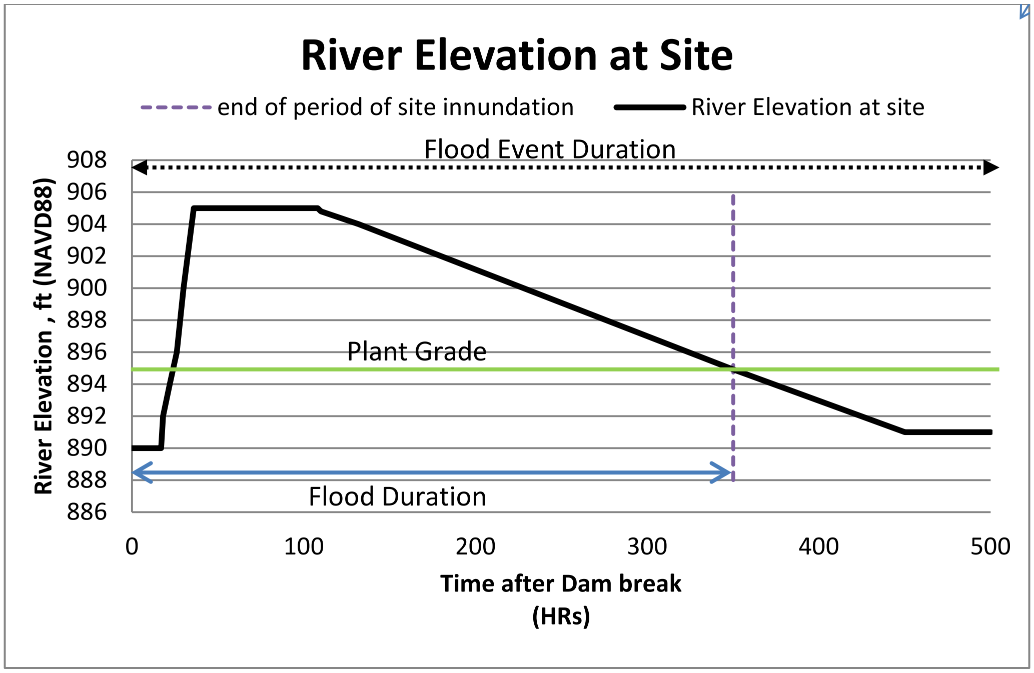


Figure 2-1: Scenario Site Flood Profile[2]

As demonstrated in the flood protection evaluation of the Integrated Assessment, the intake structure is designed for operation to the PMF and includes debris protection up to the CLB licensing level of 900 ft. Engineering Evaluation EE-SFMS-1234A “Intake Structure Clogging” (Reference 6) indicates clogging of the intake structure will not occur until plant barriers are overtopped and the service water systems can be maintained operable. Turbine driven AFW pumps can be operated and are protected to a site elevation of 904 ft. The EDG rooms begin flooding at 902 ft. EDGs are mounted and protected such that they can remain operable up to 904 ft.

It has been determined that protection cannot be provided for the existing CLB flood mitigation equipment at the new higher flood elevation. However, a mitigation strategy has been developed using a recently developed dedicated Severe Flood Mitigation System (SFMS) which provides highly reliable mitigation for flood events beyond the current 900 ft. design PMF elevation and up to an elevation of 915 ft. This system provides an alternate source of power, instrumentation and water to maintain the plant in a safe shutdown mode. Details on the Severe Flood Mitigation System are presented in Section 3.

The flood event duration for mitigation system capability initiates at the time of notification of dam breach and lasts until flood waters recede from site and the plant is in a safe and stable state that can be

2 Note Figure 2-1 illustrates the hydrograph of the river at the site, additional hydrographs illustrating the water levels within the site should be provided if they are relevant to the scenario.

maintained indefinitely. The following paragraphs provide an introductory overview of the event sequence.

The flood scenario begins with an unexpected sunny day failure of the dam. Following the failure, the plant is notified immediately by the dam operator and this can be confirmed by gauge readings downstream of the dam. Agreement AIA-001 "USACE and Utility Interface Document" (Reference 7) is in place between the dam operator and utility to assure notification of impending and existing dam failures or significant changes in dam operation that may affect the plant (see also Table 5-1). Gauge readings at upstream (of the plant) locations and predicted river levels at the site are alarmed in the control room. It is considered very unlikely that the dam will fail without prior warning signs; however no credit was taken in this assessment for detection of dam distress. The dam owner periodically inspects the dam and its condition. It's expected that prior to failure (several hours) the dam owner will notify the site of impending failure. The reduced warning time is considered to increase margin and provide conservative timing estimates for this scenario-based evaluation.

The current assessment assumes that the initial action starts at the time the dam breach is reported to the site. The Flooding Hazard Re-evaluation Report shows the flood will not cause the river level at the site to rise until at least 16 hours after failure. The first site impacts will be realized 24 hours into the event when water reaches plant grade elevation of 895 ft. and 30 hours into the event the current plant design basis flood physical protection features will be exceeded. As the flood will not reach the site grade for 24 hours, normal land access to the plant's protected area is available for 24 hours after the dam break. For additional information on site topography see Section 2.4 and 3 (Figure 3-1).

This scenario considers the plant initially operated at full power and immediately begins shutdown (AOP-1234A "Upstream Dam Failure" (Reference 8) once the dam failure is reported by the dam owner. Once initiated, an emergency shutdown is typically accomplished within 6 hours. All plant systems, offsite and emergency power is available during the shutdown. Any RCS leakage prior to reaching cold shutdown conditions is made up by the normal plant charging system. Once on shutdown cooling, the RCS pressure and temperature are reduced so as to remove temperature/pressure challenges to the RCP seals. Under these conditions RCS seal integrity can be maintained indefinitely and in this mode of operation RCS seal leakage will have a low leak rate, such that, the core will remain covered for period well in excess of the expected event duration. Given the travel time of the flood waters all plant systems are available until the flood level reaches site grade (895 ft) when offsite power will be disconnected. The RCS seal integrity is evaluated in Engineering Evaluation EE-SFMS-1234B "RCS Seal Integrity" (Reference 9) and RCS inventory is evaluated in Engineering Evaluation EE-SFMS-1234D "Decay Heat Removal and Inventory Control" (Reference 12).

Adverse site weather conditions are not anticipated following a "sunny day" dam breach. However, the mitigation capability evaluation will consider potential implications of performing the associated mitigation actions consistent with the wind speeds identified in the Flooding Hazard Reevaluation Report for the this flood hazard.

Table 2-2 provides a list of actions and significant elevations associated with the flood event duration.

Table 2-2
Significant Elevations and Action Points

Elevation (NAVD88)	Significant Elevations	Comments
915	Lower elevation of Severe Flood Mitigation System (SFMS) facility and access walkway to facility	Facility houses key flood mitigation equipment above peak flood elevation
905	Re-Evaluated Peak Flood Height	
904	TD AFW pump and EDGs Inoperable	
902	TD AFW and EDGs protection overtopped. Water begins to accumulate in these rooms.	At this elevation the TD AFW pump and the EDGs are on pedestals that will allow continued operation.
900	Plant design basis flood barriers overtopped - Lose Intake Structure and Auxiliary Building begins to flood	
898	Elevation of connection point to Well Water System and storage location for back-up air supplies and special equipment (for ADV)	-
896		Ability to move about site at 895 ft. is degraded. Walkway to the SFMS facility is located at 915 ft.
895	Operators disconnect Switchyard from Offsite Power to prevent water induced electrical failures and protect personnel	All actions that require offsite power are completed prior to water reaching this level and SFMS DG in operation.
890	Initial Water Level At Start of Event - Once confirmation that dam has breached operators will shutdown the plant	No onsite impact of flood as water level is below site grade. Site access normal. Off-site power expected to be available. Emergency power available. Plant shutdown will occur well in advance of flood waters beginning to rise.
885	SFMS submersible well water located the 885 ft. elevation	

2.3 Consideration of Associated Effects

--- *Preparer's Note* ---

The intent of this section is to consider the associated effects that are addressed Flooding Hazard Reevaluation Report within the context of the scenario being evaluated in the IA.

Flood hazards include ancillary affects that occur as a result of the flood. These effects include: wind loads, treatment of debris, water-borne missiles and hydrostatic and hydrodynamic loads, sedimentation, soil erosion, groundwater ingress and other pertinent effects. This section includes aspects of the treatment of associated effects that impacts the ability of the plant systems to mitigate the event. Detailed assessments of the protective features of these effects on the associated structures are provided in the flood hazard protection portion of the Integrated assessment

Where applicable, treatment of debris includes transport of flotsam that can clog safety systems as well as water-borne missiles (as appropriate for the site) which may damage exposed equipment or result in failure of mitigation system protective components. In instances where the hazard re-evaluation notes debris impact on external flood mitigation is not credible, provide appropriate references to that report.

In cases where the initiating event can degrade plant features as well as cause a flood hazard (e.g., seismic failure of dams), the simultaneous impact of these factors should be addressed in the integrated assessment.

2.3.1 Wind, Waves and Wave Run-up

The wind, wave and wave run-up has been included in the maximum Water Surface Elevation (WSE) and were considered in the flood protection evaluation section of the IA. The wind effects are considered in the Human Reliability Analysis (HRA).

2.3.2 Water-borne Missiles and Debris

Flood hazards also include the impact of debris. For the scenario described herein key components of the external flood mitigation system are either located above the elevation of the maximum flood site topography, or are located underground (e.g., wells) such that they are not expected to be affected by any of these factors. As access to SFMS well pumps are protected by manhole covers, debris collection within the well such that pump suction could be challenged was not considered credible (Reference 4).

The only components of that system exposed to a credible waterborne missile threat are the auxiliary feedwater injection piping and associated tees and the RWST. As large barges or other large waterborne debris are not common to the area and the flood depth is not conducive to transport of larger debris above site grade, waterborne missile transport of debris capable of damaging the AFW pipelines or

RWST were judged to not be credible. Additional discussion of the debris generated during an external flood is provided in Reference 4.

2.3.3 Hydrodynamic and Hydrostatic Effects

The only components affected by hydrodynamic affects involve piping runs from the well discharge to the steam generator feedwater piping connection. The ability of these piping runs to withstand loading associated with the floodwaters is provided in the Flood Protection Evaluation section of the overall IA for these structures. As the SFMS Facility is located above the peak flood elevation, these structures and their associated components are not subject to hydrodynamic and hydrostatic loads.

2.3.4 Sedimentation

As the river flood will transport tons of sediment to the site, the impact of sedimentation on early plant mitigation and long term recovery was considered. While sedimentation will occur throughout the site, the wells will be covered and therefore not subject to significant sedimentation. Other key equipment is generally located above the peak flood elevation and therefore not subject to the impact of sedimentation.

2.3.5 Erosion

Hydraulic and geotechnical evaluations of the design of the SFMS Facility indicate that the structure will remain stable for the entire event duration. Soil erosion may an issue in the long term as it may wash away soil above buried cables credited for powering the well water pumps. To minimize this impact cable runs are protected within seal piping runs. Erosion over an extended period of time may wash away soil underneath the SFMS Building. However, this impact is not expected to be significant in the time frame of the flood event duration.

2.3.6 Groundwater Ingress

The effects of groundwater ingress have been evaluated to not be applicable to this scenario (see Reference 4).

2.3.7 Other Pertinent Effects

There are no additional effects that are applicable to this scenario as defined in Reference 4.

2.4 Site Description and Topography

-- Preparer's Note --

The objective of this section is to sufficient topographical information of the site and surrounding area. . It is suggested that a topographical map of the site be provided. Pathways required to implement mitigation strategies and ingress to the site for offsite resources should be identified on the map and fully described herein.

Note that the discussion should include capability of air support to access site or off-site staging areas (which may be challenged by concurrent weather conditions under some flood scenarios) as well as capability to move resources from the staging area to the site.

The ability of the plant to respond to and mitigate the event is strongly dependent on the topography of the site and its environs. As the maximum re-evaluated hazard has been calculated to be 905 ft., flood mitigation electrical AC supplies have been housed in the SFMS building outside the protected site area, under the direct control of the utility, with a floor elevation of 915 ft. Section 3 of this evaluation provides the details of the SFMS building. Access to the SFMS facility and mitigation equipment is available from a highway and local roads which will be above the flood elevation. All major bridges between the surrounding community and the town are expected to remain passable for the event duration.

2.5 Long Term Mitigation and Safe Stable State

Plant functions to sustain a safe and stable state indefinitely implies the availability of reliable means of satisfying all key safety functions and that no physical/access impediment exists with regard to availability of trained personnel, a continuous means for injection into the RCS and/or steam generator as appropriate, boration capability (as needed) and a source of AC power. In this scenario, mitigation systems to be employed for long term operation may include mobile generators, transformers and associated busses capable of driving redundant injection pumps into the RCS or SG, as appropriate. Indefinite operation also implies that resources exist for the maintenance, repair and operation of the long term mitigation equipment. These features will be supplemented with support from the Regional Resource Centers.

3.0 Overview of Flood Mitigation Features

-- Preparer's Note --

The intent of this section is meant to describe the flood mitigation features/systems that are relevant to understanding the strategy and ability of the utility to protect the plant from the external flood hazard being evaluated and associated plant capabilities to mitigate the event. The primary focus should be on the systems and components that will be available and utilized to ensure that key reactor safety functions are maintained without the normal and emergency systems that may have become unavailable as a result of the hazard. These safety functions include reactivity control, reactor inventory control, decay heat removal, containment Integrity, and reactor pressure control which are described in detail in Section 6.

It is expected that components and systems have been identified specifically for this scenario and the description provided herein will demonstrate the design attributes and capabilities of the component and systems. It is important to provide functional drawings such as P&ID's, one lines, plan and elevations to aid in fully describing the mitigation features in the scenario evaluation. It is also important that details for equipment ratings, installation details such as mountings, elevations etc., be provided that will aid in demonstrating assurance that the equipment can perform the required function. Section 4.0 of this example will expand upon the component description to discuss reliability aspects of the flood mitigation equipment. This section does not invoke or imply any specific equipment operational requirements but is illustrative for the purpose of the example and provides the user with an indication of the level of detail to be presented.

3.1 Overview

As stated in Section 2, it has been determined that it is not possible to provide protection for the existing CLB flood mitigation equipment at the new flood hazard elevation. As part of the flood mitigation strategy, a Severe Flood Mitigation System (SFMS) has been designed to provide mitigation for a flood greater than the current 900 ft. design basis PMF and greater than the recalculated beyond design basis flood hazard of 905 ft. A concrete building designed in accordance with American Society of Civil Engineers (ASCE) Code 7-10 (Reference 10) has been built at an elevation of 915ft. and is located above the recalculated flood level and external to any flood plain as shown on Fig. 3-1 and Fig. 3-2. This building is designed to house power, control and monitoring equipment components and systems required to maintain the reactor in a safe and stable state. This facility is manned as part of the initial preparations for the event and prior to the onset of flood waters to the site, and is used independently from the main control room should the main control room lose function during the event. Access from the plant to the SFMS is provided by pathways at elevation 915 ft., above the recalculated flood hazard level of 905 ft. as shown on Fig.3-1 and Fig. 3-2, and not subject to hydrostatic or dynamic failures as a result of the event. The SFMS has sufficient stores (food, drinking water, and housing) to support the required operating staff for a period of 15 days. Once the SFMS is activated control of the event will be from this facility. Personnel will be dispatched from the SFMS facility as needed. External access to the SFMS building is from multiple roads that are not within the flood plain and are not expected to be flooded or debris laden, as confirmed by topographical survey. These roads effectively connect the SFMS building with surrounding communities and provide road access for resupply of the SFMS facility (fuel, stores, equipment). A helipad area is also adjacent to the SFMS building to allow ready access for airborne supplies. The facility has connection stations for fuel and electrical power. Building lighting, pathway egress/ingress and ventilation are powered by the SFMS Motor Control Center (MCC). Although not normally manned, the building is monitored by normal operator rounds.

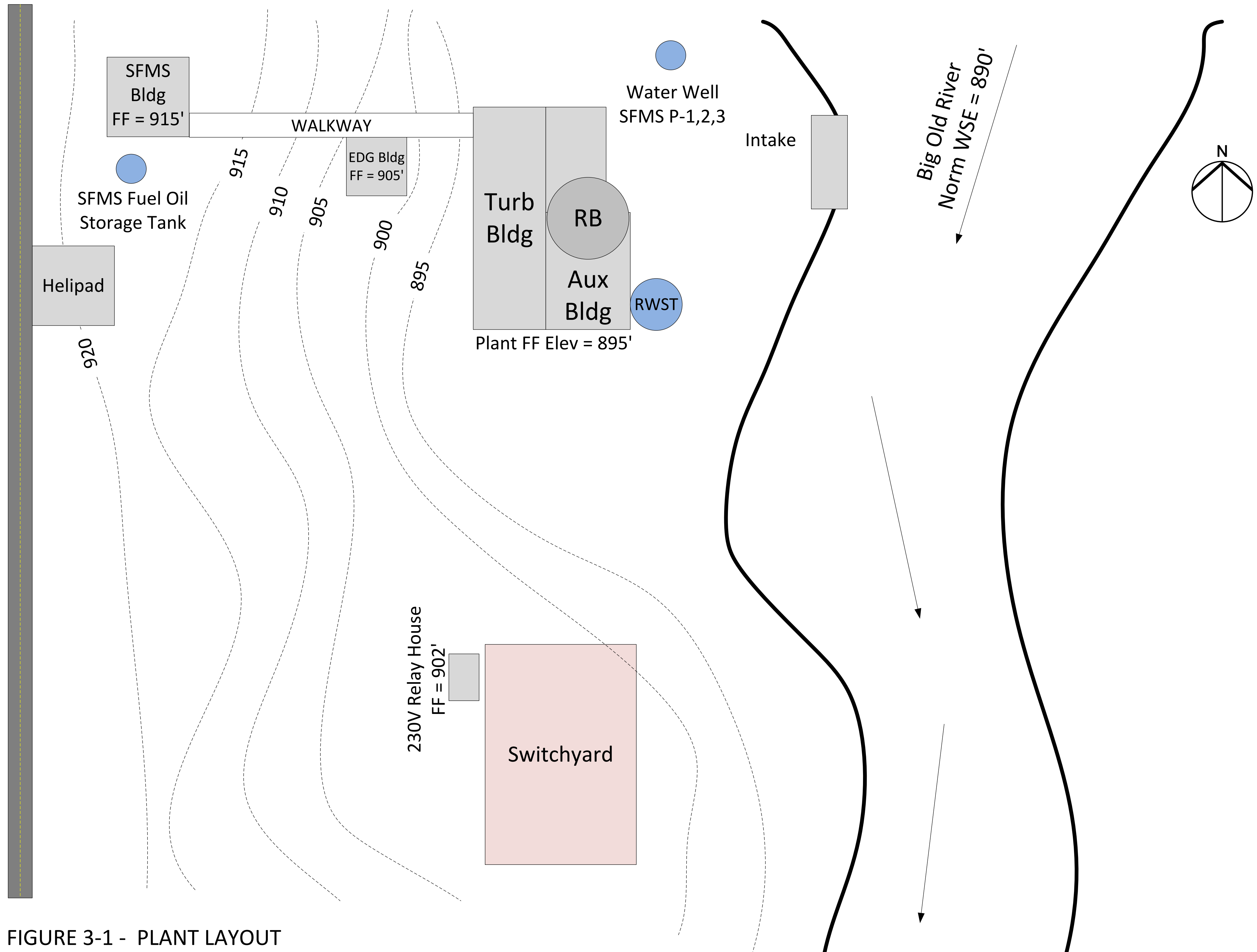
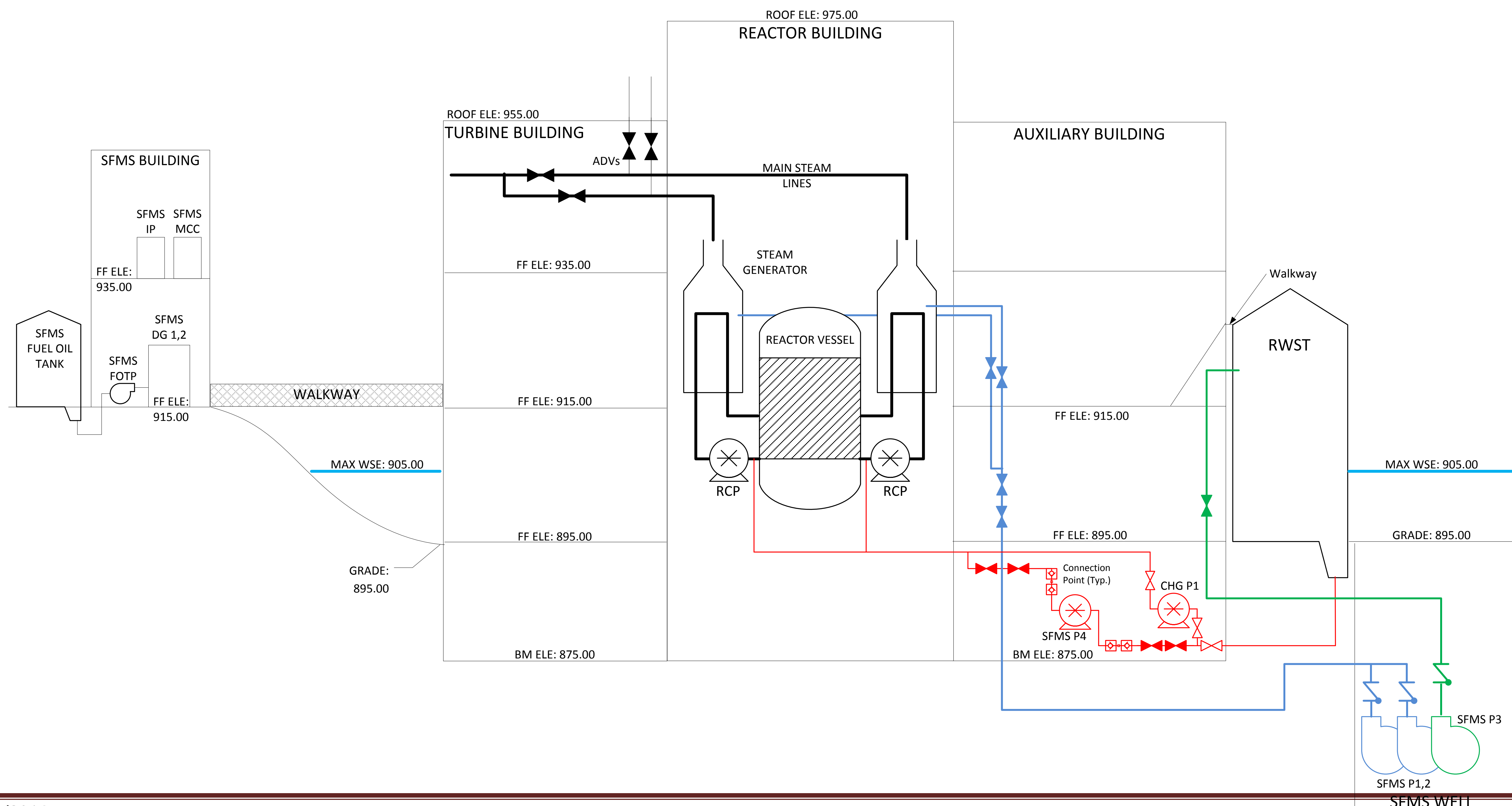


FIGURE 3-1 - PLANT LAYOUT

NOT TO SCALE

FIGURE 3-2
SIMPLIFIED PLANT ELEVATION DRAWING
Not To Scale



3.2 Severe Flood Mitigation System

Electrical Power

The SFMS consists of the power, controls, pumps, valves, connections and monitoring equipment to maintain the reactor in a safe and stable state. Two (2) air cooled skid mounted self-contained diesel engines powering 500kva 480volt air cooled generators are provided to provide power to all required SFMS components. Each SFMS diesel generator set is designed to provide sufficient capacity, starting kva and voltage to operate all SFMS equipment as well as the lighting, ventilation, and other house loads of the SFMS building. Each SFMS diesel generator set is connected to one (1) 480v, 600amp, SFMS MCC that contains the operating controls for the SFMS components. Only one SFMS diesel generator set is needed and is connectable to the SFMS MCC via a kirk-key, manually operated transfer switch located within the SFMS MCC. Cabling from each SFMS diesel generator set to the SFMS MCC is routed via embedded conduit and raceway completely within the building. The SFMS MCC is normally connected to station power via an underground cable but is disconnected when the SFMS facility is activated and station power is presumed lost via manually opening a circuit breaker at the SFMS MCC. The SFMS MCC services the loads identified in Table 3-1.

A 125v, 500 ampere hour SFMS DC battery is provided and is connected to a 125vdc power panel. This panel provides 125vdc power to all required SFMS DC loads. The SFMS 125vdc power panel normally receives power from a 480v/125vdc 250 amp battery charger that is connected to the SFMS MCC. The battery charger is sized to carry the SFMS DC loads and recharge the battery in 12 hours. Should the SFMS MCC fail to provide power to the charger, the battery is designed to meet the required loads for 16 hours. This time is sufficient to allow the alternate SFMS diesel generator set to be connected to the SFMS MCC. All cable connections are routed in embedded conduit or raceway completely within the SFMS building.

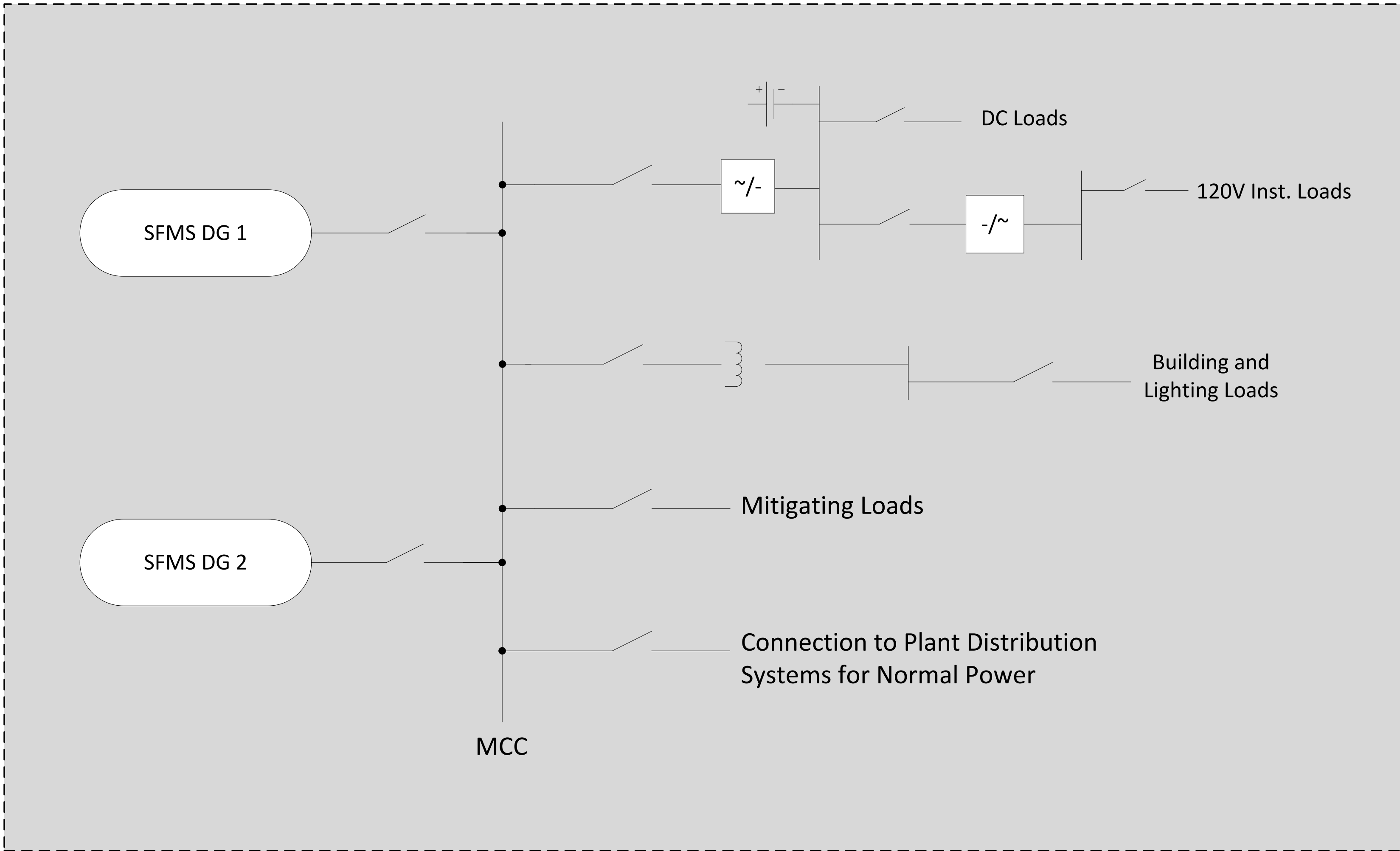
A 120vac 5kva SFMS inverter is also provided. The SFMS inverter is connected to the 125vdc SFMS power panel and provides power directly to a 120vac power panel that in turn provides power to the SFMS instrumentation loads. All cable connections are routed in embedded conduit or raceway within the SFMS building.

Analysis of the SFMS power system is contained in Engineering Evaluation EE-SFMS-1234C “SFMS Power System” (Reference 11)

A simplified one line diagram illustrating the SFMS electrical system is shown in Fig. 3-3.

All equipment housed within the SFMS facility has been procured commercial grade and are part of the plants normal operational, maintenance and engineering programs (see Section 4). Additionally, spare equipment (multiple spare connectors and cables) are available during the flood and stored in the building.

FIGURE 3-3 – Simplified Diagram of SFMS Electrical Distribution



SFMS BUILDING

Decay Heat Removal and RCS Inventory Control

In order to provide decay heat removal during this event, two (2) submersible 250 gpm centrifugal SFMS pumps 1 and 2 have been provided to take suction from a well located on the flood plain evaluated to have sufficient capacity to meet the inventory requirements of the event. Each SFMS pump has sufficient capacity to provide up to three (3) times that necessary to remove decay heat in excess of 12 hours after shutdown. Piping is installed between the SFMS well pumps and steam generator feed lines such that each SFMS well pump feeds one steam generator. Delivery to the steam generators is affected by injection through a tee connection to the AFW Lines. Two manually operated valves are provided to isolate the piping connection inlet flange from the AFW lines.

The SFMS pumps are powered from the SFMS MCC located in the SFMS building and are electrically connected via approximately 2000 ft. of 4/0 AWG cable installed in underground duct bank. The conduits within the underground duct bank are sealed at the last manhole and at the building entrance to preclude any water path into the building. These seals are considered flood barriers and have been evaluated in the flood protection section of the Integrated Assessment.

To provide makeup to the RCS, an installed 25 gpm positive displacement SFMS pump 4 is provided. The pump is connected to the RCS by a pipe and manual valve scheme that allows the SFMS pump 4 to take suction from the suction side of the existing charging pump (Refueling Water Storage Tank (RWST)) and pump into the discharge of the existing charging pump (RCS). The SFMS submersible pump 4 is powered by a 7.5hp 460v motor and is connected to the 480v SFMS MCC via 2- 1/c # 8 AWG in sealed underground duct. Alignment of SFMS pump 4 to the RCS is as per procedure AOP 1234A. Prior to the flood reaching the site, the RWST is filled with borated water per plant technical specifications. To provide water to the RWST, a 50 gpm centrifugal SFMS pump 3 has been provided to take suction from a well located on the flood plain. The SFMS pump 3 is powered by a 15hp 460v motor connected to the 480v SFMS MCC via 2-1/c #6 AWG in sealed underground duct and is controlled from the SFMS MCC. Alignment of SFMS pump 3 is also covered by procedure AOP 1234A. Boric Acid crystals can be added to the RWST via an upper man way to the tank in accordance with plant procedure AOP 1234A. A simplified diagram of the SFMS feedwater and RCS make up systems is provided in Fig. 3-4.

Analysis of the Decay Heat Removal and RCS Inventory Control is contained in Engineering Evaluation EE-SFMS-1234D "Decay Heat Removal and Inventory Control" (Reference 12).

Instrumentation and Control

Instrumentation required to monitor the RCS, and decay heat removal parameters is provided on the SFMS Instrument panel located in the SFMS facility. Two channels each of Steam Generator Level, Steam Generator Pressure, RCS Pressure, RCS Temperature, pressurizer level, and Containment Pressure are provided on the panel. The panel receives power from the 125vdc SFMS panel and the 120v SFMS inverter system. The system is completely contained within the SFMS building with exception of the incoming channel cables which enter the building in underground sealed duct. Control of the SFMS components is from the SFMS MCC via start/stop switches on the SFMS MCC doors.

Analysis and setpoints for the SFMS instrumentation is contained in Engineering Evaluation EE-SFMS-1234E “SFMS Instrument Setpoints” (Reference 13).

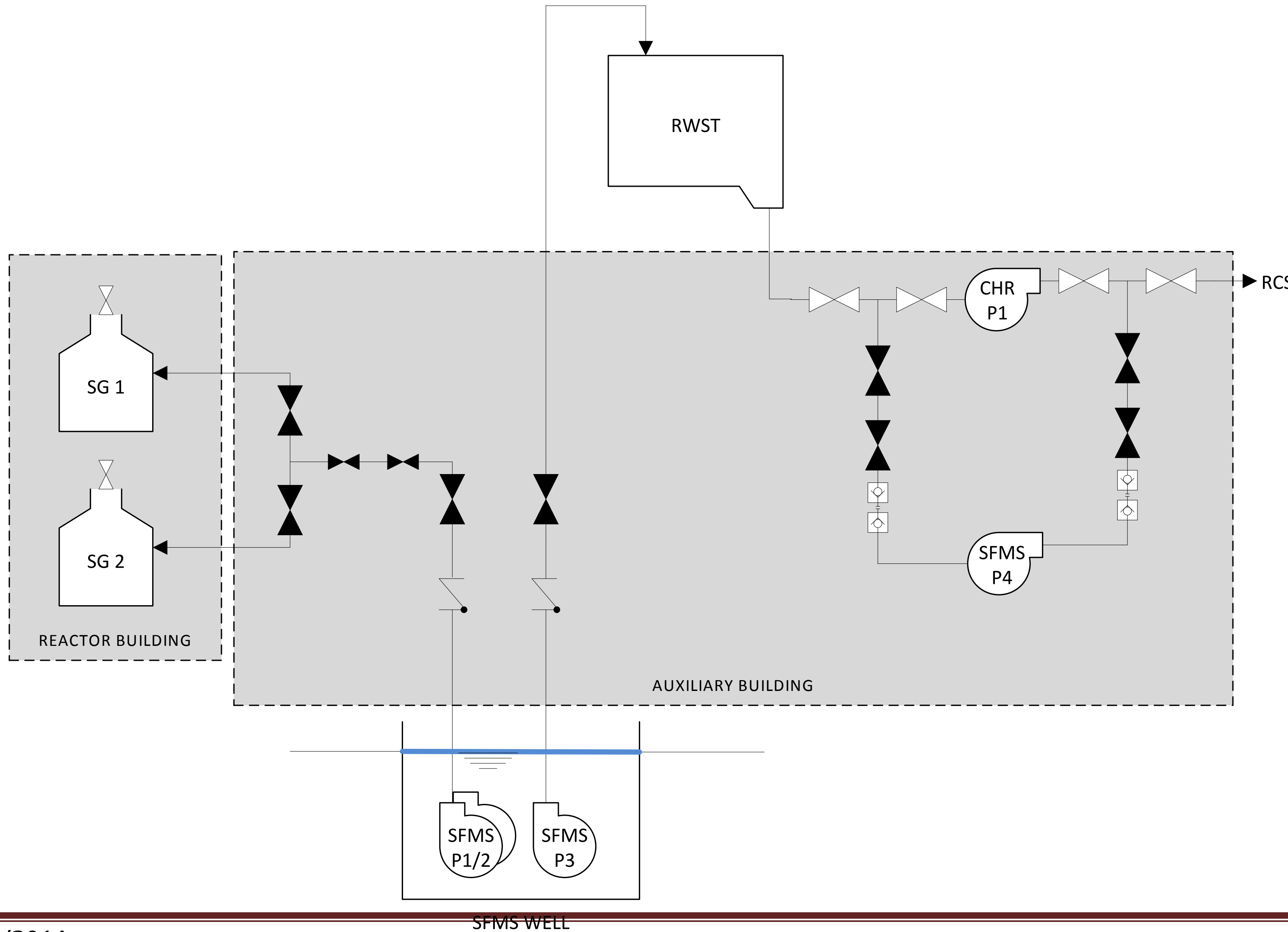
Diesel Fuel Oil Supply System

Each SFMS DG is provided with a 75 gallon day tank mounted on the SFMS DG skid. When full, the fuel oil day tank is capable of storing sufficient fuel to feed the SFMS DG for at least 24 hours. Each fuel tank can be resupplied via connections to a 10,000 gallon Fuel Oil Storage Tank located outside the SFMS building. Fuel supplies to the SFMS DGs can be cross tied. Power to the SFMS Fuel Oil Transfer Pumps (FOTP) is from the SFMS MCC and is controlled from the SFMS MCC or thru an external, local control station adjacent to the 10,000 gallons SFMS tank. Several contracts with local fuel oil dealers are in effect that would allow transport of a fuel oil truck with [X] gallons of fuel to be provided to the site on [x] hours notice. Fuel transfer from the external storage tank to the day tank is automatic and refills when the day tank fuel level drops to the 25% level. The FOTP has a 7.5 gpm capacity. The tanker truck is to be parked in a lot outside of the SFMS building and serves as the long term fuel oil makeup for the external fuel oil tank or may be directly connected to the SFMS oil fill line. The fuel oil level is read from a sight gauge within the SFMS facility on the day tank and fuel oil storage tank.

Analysis of the Diesel Fuel Oil Supply System is contained in Reference 11.

Table 3-1 Functional Description of Severe Flood Mitigation System (SFMS)	
Component	**Function**
Two 250 gpm capacity SFMS well pumps 1&2 and piping	Redundant SG makeup capability
One 50 gpm capacity SFMS well pump 3 and piping	Makeup to RWST
One 25 gpm positive displacement SFMS pump 4 and piping	RCS Makeup
SFMS fuel oil transfer pump and hoses	Transfer of fuel from external tank / truck to day tank
Well and groundwater	Water source for SG feed
Two SFMS Diesel Generators (redundant power supply)	To provide emergency AC power following an SBO
SFMS Motor Control Center and Power Distribution Panels	Power distribution and connection to SFMS AC loads
SFMS Battery and Charger-	Power distribution and connection to SFMS DC loads
SFMS 120V Inverter	Power distribution and connection to SFMS uninterruptible loads
SG ADVs/MSSVs	Used for steam relief paths
Mechanical gagging devices/equipment	Keep ADV/MSSVs open
Manual valves	Complete connection between SFMS well pumps 1, 2 and 3, SG feed and RWST connection; connection of the SFMS makeup pump 4 to the RCS.
SFMS Building	House and protect SFMS DGs, and staff for event duration.
SFMS Well Pumps 1,2 &3 and SFMS Make-up pump 4 discharge flow meters	Devices to confirm continued effectiveness of strategy
SFMS DG Fuel Level (Local on tank.)	Monitor SFMS DG Fuel Oil Level
Commodities • Food • Potable water	Support for site personnel
Instrument Panel • SG Level and Pressure • RCS Temperature and Pressure • Containment Pressure • Pressurizer Level • Refueling Water Storage Tank Level	Instrument feed routed to and displayed at SFMS facility

FIGURE 3-4 – Simplified Diagram of SFMS Auxiliary Water Distribution



4.0 System Capability/Reliability Assessment

-- Preparer's Note --

A detailed evaluation, in accordance with Appendix A of JLD-ISG-2012-05, should be provided for each component or class of components that are required to change state and not part of normal plant safety related equipment. A typical list of components for this example is provided below. However, the SFMS DGs were fully evaluated for the purpose of this example and the SFMS Well Water Pumps (P-1 & 2) were shown as a template. The following is a representation as to what may be included in the remainder of the reliability assessment section. In the table below, the parenthetical "not provided in example" will be required information for a complete IA but will not be included in this example.

This section of the example is intended to address Section 7.2 of the ISG.

This section provides the technical support for assessing the capability and reliability of the key components credited in the current scenario.

4.1 Severe Flood Mitigation System Reliability Assessment

Each active component or class of components included in the mitigation system is included in Table 4-1. The components shown include all components that change state or are required to be positioned prior to use. These components are then compared with the criteria included in Table A.1 of Appendix A of the ISG. Table 4-1A illustrates SFMS DG's capability assessment and reliability assessment of key active components is provided in Table 4-3.

A review of Table A.1 of the ISG indicates that all the functional, operational, unavailability and storage characteristics expectation are met (See Table 4-1A). The following is an example as to what may be included in the remainder of the reliability assessment section. The only component that does not have a table provided in the section below is the ADVs. These will be operated well in advance of the flood water arrival and all normal plant equipment will be available. Therefore, it is concluded to be highly reliable.

All components supporting the mitigation of severe floods are maintained to ensure that the equipment is reliable and available. To ensure these components are periodically maintained, surveilled, and tested they are included within plant maintenance programs.

Table 4-1
Active Components Credited in SFMS Design

Component	Number	Manufacturer Identification /Plant ID	Table
Diesel Generators SFMS DG 1&2	2		See Table 4-1A
Submersible Well pumps SFMS Pumps-1 & 2	2		See Table 4-1B
Submersible Well pumps SFMS Pump-3	1		See Table 4-1X (Not provided in example)
Submersible Portable RCS Make Up Pump SFMS Pump-4	1		See Table 4-1X (Not provided in example)
SFMS Battery and Charger	1		See Table 4-1X (Not provided in example)
Inverter	1		See Table 4-1X (Not provided in example)
SFMS MCC Breakers, Controls and Monitoring Meters	1	Generic item	See Table 4-1X (Not provided in example)
SFMS Distribution Panel Breakers	3		See Table 4-1X (Not provided in example)
Installed Lighting (plant egress/ingress and SFMS)	Various	Generic Plant Item	See Table 4-1X (Not provided in example)
Portable Lighting	Various		See Table 4-1X (Not provided in example)
SFMS Instrumentation Panel with instruments	1		See Table 4-1X (Not provided in example)
Manual Valves (connection points)	9		See Table 4-1X (Not provided in example)
SFMS Diesel Fuel Oil Transfer Pump	1		See Table 4-1X (Not provided in example)
ADVs/MSSVs	2		Components will be actuated under normal plant conditions and operated within design limits.

Table 4-1A
Assessment of Active Components
Comparison of System Capability to Table A.1 of JDL-2012-ISG-05 Appendix A
(EXAMPLE TABLE)

Component: SFMS Diesel Generators (DG-1/2)	
Functional characteristics 1. Equipment is capable of performing its required function (e.g., functional requirements such as pump flow rate, pump discharge pressure are met).	Each SFMS DG is sized to power all required loads on the SFMS MCC with 25% margin. Functional characteristics of DG is included in [Appendix] SFMS DGs are air cooled and have no external dependency other than fuel, and ventilation for air cooling. Each SFMS DG is redundant to each other and spare parts and repair manuals are available within the SFMS facility should on site repair be needed
2. Equipment is in satisfactory condition.	MST-SFMS-1234A (Reference 14). Includes instructions to check, lubricate, replace key components based on manufacturer recommendations to ensure high reliability. This procedure also includes staggered [quarterly] testing of each SFMS DG ability to start and run for [30] minutes. One [24] hour SFMS DG test is performed [yearly].Maintenance and testing at this frequency is intended to ensure high reliability of components
3. Functionality of the equipment may be outside the manufacturer's specifications if a documented engineering evaluation justifies that the equipment will be functional when needed during the flood event duration.	Equipment is commercial grade and will be operated within manufacturer's specifications. **[Preparer: Note any exceptions].** Equipment tested periodically (See above).
4. There is an engineering basis for the functional requirements for the equipment which: a. Is auditable and inspectable; b. is consistent with generally accepted engineering principles; c. defines incorporated functional margin; and d. is controlled within the configuration document control system.	SFMS DG functional requirements Controlled by Engineering Processes. [Note procedures and support/sizing calculations are provided in the reference 11] After 3 days, replacement DGs and pumps will be available from the Regional Response Center.
Operational Characteristics 1. Equipment is covered by one of the following: a. existing quality assurance (QA) requirements in Appendix B of 10 CFR Part 50; existing fire protection QA programs; or b. a separate program that provides assurance that equipment is tested, maintained, and operated so that it will function as intended and that equipment reliability is achieved.	**[Provide manufacturer characteristics data and DG loading.]** See Appendix Equipment is covered under a separate classification within the plants maintenance program that provides assurance that equipment is tested, maintained, and operated so that it will function as intended and that equipment reliability is achieved. See Reference 14.

Table 4-1A
Assessment of Active Components
Comparison of System Capability to Table A.1 of JDL-2012-ISG-05 Appendix A
(EXAMPLE TABLE)

Component: SFMS Diesel Generators (DG-1/2)	
2. Testing (including surveillances) a. Equipment is initially tested or other reasonable means should be used to verify that its performance conforms to the limiting performance requirements. b. Periodic tests and test frequency are determined based upon equipment type and expected use. Testing is done to verify design requirements and basis are met. The basis is documented and deviations from vendor recommendations and applicable standards should be justified. c. Periodic inspections address storage and standby conditions as well as in-service conditions (if applicable). d. Equipment issues identified through testing are incorporated into the corrective action program and failures are included in the operating history of the component. 3. Preventive maintenance (including inspections) a. Preventive maintenance (including tasks and task intervals) is determined based upon equipment type and expected use. b. The basis is documented and deviations from vendor recommendations and applicable standards should be justified. c. Periodic testing addresses storage and standby conditions a well as in-service conditions (if applicable) d. Equipment issues identified through inspections are incorporated into the corrective action program and failures are included in the operating history of the component.	Equipment is initially tested to verify that its performance conforms to the limiting performance requirements Reference 14, state the requirements The SFMS DGs are subjected to a [quarterly sequential] test program (Reference 14). Testing is done to verify system functionality (i.e., component starts and runs). The test program designed to avoid excessive SFMS DG wear. The basis for the test program is contained documented in Reference 14. No deviations from vendor recommendations and applicable standards are taken. Preventive maintenance is performed in accordance with manufacturer's specifications, as documented in Reference 14. Administrative controls exist such that Equipment issues identified through testing or inspections are incorporated into the corrective action program and failures are included in the operating history of the component.
Unavailability Characteristics 1. The unavailability of equipment should be managed such that loss of capability is minimized. Appropriate and justifiable unavailability time limits are defined as well as remedial actions. A replacement would be for equipment that is expected to be unavailable in excess of this time limit or when a flood event is forecasted. 2. A spare parts strategy supports availability considerations. 3. The unavailability of installed plant equipment is controlled under existing plant processes such as technical specifications.	Unavailability of any one SFMS DG is limited to [x] weeks. Note during low reservoir water conditions and with communication from the dam owner longer outages may be established. Unavailability under no circumstances (without replacement) will exceed [x] weeks. To minimize time for repair adequate spare parts for active components are maintained in a storage area adjacent to the SFMS building.
Equipment storage characteristics 1. Portable equipment is stored and maintained to ensure	The SFMS DGs are located in a building designed to ASCE 7-10 located at 915 ft. elevation (above maximum elevation of re-

Table 4-1A
Assessment of Active Components
Comparison of System Capability to Table A.1 of JDL-2012-ISG-05 Appendix A
(EXAMPLE TABLE)

Component: SFMS Diesel Generators (DG-1/2)	
that it does not degrade while being stored and that it is accessible for maintenance and testing. 2. Credited active equipment is protected from flooding. It is accessible during a flooding event. Alternatively, credited active equipment may be stored in locations that are neither protected from flooding nor accessible during a flood if adequate warning of an impending flood is available and equipment can be relocated prior to inundation. a. Consideration should be given to the transport from the storage area recognizing that flooding can result in obstacles restricting normal pathways for movement. b. Manual actions associated with relocation of equipment should be evaluated as feasible and reliable (see Appendix C to the ISG guidance). 3. A technical basis is developed for equipment storage that provides the inputs, assumptions, and documented basis that the equipment will be protected from flood scenario parameters such that the equipment could be operated in place, if applicable, or moved to its deployment locations. This basis is auditable, consistent with generally accepted engineering principles, and controlled within the configuration document control system.	evaluated hazard The SFMS DG are permanently installed and positioned in an operational condition within the SFMS structure. Transportation considerations are therefore not applicable. Actions to implement the system are discussed in Section 7.

Table 4-1B
Assessment of Active Components
Comparison of System Capability to Table A.1 of JDL-2012-ISG-05 Appendix A
(EXAMPLE TABLE)

Component: Submersible SFMS Well Pumps (P-1 & 2)	
Functional characteristics 1. Equipment is capable of performing its required function (e.g., functional requirements such as pump flow rate, pump discharge pressure are met).	**To be Completed by Utility**
2. Equipment is in satisfactory condition.	
3. Functionality of the equipment may be outside the manufacturer's specifications if a documented engineering evaluation justifies that the equipment will be functional when needed during the flood event duration.	
4. There is an engineering basis for the functional requirements for the equipment which: a. Is auditable and inspectable; b. is consistent with generally accepted engineering principles; c. defines incorporated functional margin; and d. is controlled within the configuration document control system.	
Operational Characteristics • Equipment is covered by one of the following: a. existing Quality Assurance (QA) requirements in Appendix B of 10 CFR Part 50; existing fire protection QA programs; or b. a separate program that provides assurance that equipment c. is tested, maintained, and operated so that it will function as intended and that equipment reliability is achieved. • Testing (including surveillances) a. Equipment is initially tested or other reasonable means should be used to verify that its performance conforms to the limiting performance requirements. b. Periodic tests and test frequency are determined based upon equipment type and expected use. Testing is done to verify design requirements and basis are met. The basis is documented and deviations from vendor recommendations and	

Table 4-1B
Assessment of Active Components
Comparison of System Capability to Table A.1 of JDL-2012-ISG-05 Appendix A
(EXAMPLE TABLE)

Component: Submersible SFMS Well Pumps (P-1 & 2)	
applicable standards should be justified. c. Periodic inspections address storage and standby conditions as well as in-service conditions (if applicable). d. Equipment issues identified through testing are incorporated into the corrective action program and failures are included in the operating history of the component. • Preventive maintenance (including inspections) a. Preventive maintenance (including tasks and task intervals) is determined based upon equipment type and expected use. b. The basis is documented and deviations from vendor recommendations and applicable standards should be justified. a. Periodic testing addresses storage and standby conditions as well as in-service conditions (if applicable). c. Equipment issues identified through inspections are incorporated into the corrective action program and failures are included in the operating history of the component.	
Unavailability Characteristics	
Equipment storage characteristics	

[Add additional tables, as needed]

4.2 Maintenance, Testing and Surveillance Assessment

-- Preparer's Note --

This section provides important highlights of the programs for equipment relied upon to support the external flood mitigation strategy. Include listing and brief description of relevant aspects of maintenance, testing/surveillance and implementation procedures used in preparing flood mitigation equipment.

Any standards or references used to demonstrate reliability should be verified to be the latest version, if available.

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All components used for the flood mitigation process are commercial grade, and are operated within their design capacities. Components are non-safety grade, but are maintained in accordance with the site maintenance program for equipment important to safety. Components receive periodic preventive maintenance in accordance with manufacturer specifications. Active components are tested [annually], prior to flood season, to ensure system is operational and can be operated within expectations.

An adequate supply of replacement parts (or spare components) is available on site at the SMSF building to address reasonably expected maintenance. Plant staff has the necessary skills and training to implement any repairs/replacements. Repair parts are stored in a flood and seismically secure location which is readily accessible to the maintenance staff. As a consequence of the equipment and spare part availability, functional failures of decay heat removal capability are not considered likely. Table 4-2 provides a summary of the maintenance, testing and surveillance programs governing the use these systems and components.

Table 4-2
List of Governing Procedures

System/Component	Maintenance Procedures	Surveillance /Testing
SSCs used to support normal operation and shutdown (e.g. SDC system, Instrument air compressors, etc.)	Equipment treatment consistent with 10CFR50.65 (Reference 17) and specific maintenance procedures.	Surveillance and testing consistent with technical specification requirements and other regulatory restrictions for specific equipment
SFMS	Maintenance procedures invoked based on type of component and manufacturer recommendations.	MST-SFMS-1234A provides overall system surveillance and test requirements for the integral system and strategy.
SFMS DG's	MST-SFMS-1234A. Includes instructions to check, lubricate, replace key components based on manufacturer	MST-SFMS-1234A. Procedure includes staggered [quarterly] testing of SFMS DG ability to start and run for [30] minutes.

Table 4-2
List of Governing Procedures

System/Component	Maintenance Procedures	Surveillance /Testing
	recommendations to ensure high reliability.	One [24] hour DG is performed [yearly].
SFMS Well Water pumps	MST-SFMS-1234A	MST-SFMS-1234A. SFMS P-1 & 2 are tested for ability to start periodically and maintained periodically refurbished during low challenge seasons
SFMS DG Fuel Oil and SFMS FOTP	MST-SFMS-1234A	MST-SFMS-1234A. Oil quality checked [monthly]. SFMS FOTP and associated lines checked to ensure clear of debris and functional

4.3 Component Reliability Estimates

-- Preparer's Note --

This section provides available quantitative information on the reliability of components involved in the successful operation of the SFMS. Information reported in this section includes estimates of component failure to start (per demand) and run time failure rates. This information may be established from information available from the equipment manufacturer, data obtained from generic reliability data books on similar components operated in similar environments and may be Bayesian updated based on past experience with these or similar components. Reliability estimates should consider the component operational environment, any relevant plant operational experience and maintenance regimen. The rates shown in Table 4-3 are shown as part of the example and not necessarily endorsed rates.

It should be noted that the NRC recognizes that plant equipment used for extreme flood mitigation may not have sufficient reliability data and it may not be as rigorously developed as nuclear grade safety related equipment. When quantification cannot be otherwise established the ISG Section A.1.2.1 should be followed. It should also be noted that additional information (e.g., description of whether considerations such as a pump running under submerged conditions affects its reliability) may be needed to support staff review of an actual submittal.

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Tables 4-1a through 4-1x provide a qualitative process for confirming that equipment assigned to external flood mitigation have high reliability and availability. Section 4-2 identifies the various programs that define the treatment regime for these components and highlights the key aspects of those specific programs. While reliability of these components is expected to be high, no specific reliability values or component failure rates are identified. This section provides estimates of the component failure rates.

While normal plant SSCs are tracked on plant specific and industry-wide bases, considerable information is available for estimation of component reliability. However, many of the components used in the SFMS are new to nuclear plant applications and may not have the advantage of a pedigreed reliability database. Where available, applicable manufacturer provided reliabilities are reported. However, for many active components of the SFMS no specific reliability values are available. In those instances, reliabilities of key active components are obtained from generic estimates of commercial grade equipment of similar classes and sized components. The reliability estimates for SFMS components are presented in Table 4-3.

Table 4-3
Reliability Evaluation of Key Systems/Components Credited in Flood Mitigation System Design

Component	Failure Rate	Basis
SFMS P-1,2,3,4 fail to run	1x 10^{-4}/hour	Mean failure rate for run failure based on generic value estimated from operation of low pressure, low flow, and low pressure electric driven pumps. Considers data from IEEE and NPRDS
SFMS P-1,2,3,4 fail to start	0.001/demand	Pump start failure based on manufacturer provided information. The pumps are subject to plant testing and maintenance program (see Table 4-2).
SFMS DG-1/2 fail to run	5 x10^{-5}/hr	Mean failure rate for run failure based on generic failure values of low voltage, low power DG. Considers data from IEEE and NPRDS.
SFMS DG-1/2 fail to start	0.01/demand	Mean failure to start based on engineering judgment. SFMS DG included in periodic maintenance program.
Failure rate of Electrical Switches and Breakers	[1/20,000]/demand	Specific reliability of components are unavailable however, reliability traditionally very high. Estimated failures based on representative switches/breakers.
Failure of SFMS Storage Tank) to Feed SFMS DG (manual valve fails to open)	0.001/demand	Manual valve connection. Typical of Generic data. Valves surveilled routinely and tested periodically.

4.4 Equipment Dependencies

Knowledge of equipment dependencies is important in assessing overall system reliability and in identifying potential common cause issues. Equipment dependencies associated with components in the flood mitigation strategies have been identified for the following components:

- ADVs
- SFMS DGs (SFMS DG-1, 2)
- Well water pumps (SFMS P-1, 2, 3)
- Instrumentation

These dependencies are identified in Table 4-4.

Atmospheric Dump Valves: Atmospheric dump valves are used to depressurize the SGs and cool down the RCS in a controlled manner. The ADVs are opened by air operated valves that receive air supply from the normal instrument air system. In preparation for a flood event, the ADVs will be opened and mechanically prevented from closing via use of specially designed tool prior to the flood waters reaching the site.

SFMS DGs (SFMS DG-1 & 2): The operability of SFMS DGs are critical to the flood mitigation strategy. The SFMS DGs are air cooled and may be started using a self-contained starter system. SFMS DGs are run on standard diesel fuel. An adequate fuel supply is assured by the fuel stored within the 10,000 gallon SFMS fuel oil storage tank and the operability of a diesel driven Fuel oil transfer Pump (Reference 11). Procedures are available to refill the fuel oil tank via external oil tanker trucks and gravity feed procedures are in place to assure a continuous supply of oil to the SFMS DG should the FOTP fail. While building HVAC is available once the DGs are operating, an adequate operational environment may be established by manual operation of building vents. As the SFMS DG is housed above the flood plain in an ASCE-7-10 structure, the SFMS DGs are well protected from the effects of the flood and any associated harsh environment.

SFMS Well pumps (SFMS P-1, 2 & 3): SFMS well pumps are rugged and designed to operate submerged. The pumps depend on the groundwater for an inventory source. Pumps are electrically driven and are powered by the SFMS DGs. Fill and soil surrounding the pump provide adequate filtration of water into the pump to prevent clogging of the intake filter. Well pumps SFMS P-1 and 2 are aligned to the SGs, and will begin injecting into a depressurized steam generator prior to site flood and will continue to operate throughout the event. Flow control is available through a remotely operated flow control valve. SFMS P-3 is an alternate means to refill of the RWST and is not anticipated to be used unless RWST inventory runs low. Operators will place the pump into operation, if needed, and terminate its use after the RWST has been refilled in accordance with TS.

RCS Portable Inventory Makeup Pump (SFMS P-4): This pump is a low capacity, moderate pressure electrically driven submersible pump and will be staged on the 875’ elevation of the auxiliary building.

The pump takes suction from the RWST and pumps into the cold leg of the RCS. It is powered from the SFMS DGs and remotely operated by the plant staff located in the SFMS building.

Instrumentation: Instrumentation panels in the SFMS are powered by dedicated instrument batteries. Once the SFMS DGs are operating, the batteries receive a continuous charge from a charging system

Table 4-4
Dependencies/Support Systems for Active Flood Mitigation Components

Component	Primary Support Systems	Secondary Support Systems	Additional
ADVs	IA-01 MD-1 (initial 24 hours preparations	BAT-1 N2-01 MSSVs (initial 24 hours preparations)	Mechanical device to open and prevent closure
SFMS DG-1&2	SFMS DG Fuel Oil Day Tank and SFMS Fuel Oil Tank SFMS HVAC and Ventilation	SFMS Fuel Oil Tank Truck	Fuel Oil Truck with compatible connecting hose Gravity feed available
SFMS P-1&2	SFMS DG-1 /SFMS MCC Instrumentation Groundwater	SFMS DG-2/SFMS MCC	Once SFMS pumps are operational and system operation is confirmed, pump operation is not prevented by unavailability of instrumentation.
SFMS P-3	SFMS DG-1 /SFMS MCC Instrumentation Groundwater	SFMS DG-2/SFMS MCC	Once SFMS pumps are operational and system operation is confirmed, *guidance is available in AOP-1234A to the operating staff to continue long term operation of the steam generator feed pumps in the event of an extended loss of instrumentation.*
SFMS P-4	SFMS DG-1/SFMS MCC RWST	SFMS DG-2/SFMS MCC	SFMS P-3 may be used to provide make-up to the RWST in the event significant levels of injection are required.
Instrumentation	SFMS DC-Distribution Panel SFMS DG-1 & MCC	SFMS DC-Distribution Panel SFMS DG-2 & MCC	
IA –Plant Instrument Air Compressor BAT – Plant Battery N2 - Nitrogen Bottle MD – Mechanical Device			

5.0 Event Timeline and Resource Loading

-- Preparer's Note --

The intent of section 5 is to provide information regarding the timing of events and key actions for the mitigation strategy. Two representations have been included to demonstrate an option with a greater level of detail in Table 5-1 and graphical concise representation in figure 5-1.These figures have been provided to give examples of methods to convey the necessary information about the strategy.

The preparer must factor all resources required on site and this resource loaded schedule should not be limited to flood specific actions. In instances where multiple safety and non-safety activities are being performed, administrative guidance on task prioritization and resource allocation should be provided. Also include administrative guidance that will be used for employing resources. It is not the intent of this example to discuss any other non-essential actions. This discussion should include expectations to ask for exemptions from normal workrule requirements. While an exemption will not be necessary if an Emergency is declared, the time period just before and just after a flood will have to be carefully managed in accordance with Part 26 to avoid fatigue-related errors.

This section provides information regarding the scenario timeline of hazard and plant responses. A tabular timeline is provided (see Table 5-1) with links to supporting sections where supplementary supporting information may be found. A graphical display is also provided (see figure 5-1) which expands on the details regarding how plant manpower resources are used throughout the scenario. This section also includes consideration of resources required to achieve the key safety functions, alternative resources to perform investment protection and related functions not directly related to protecting the reactor core or spent fuel. The distribution of resource capabilities are also provided to demonstrate that ample staff will be available to perform the critical protective and mitigation activities.

The graphic timeline visually demonstrates the activities required for flood mitigation before, during and following the event. This timeline starts with the actual dam breach and shows the activities that are required by procedure following the initiation of the event. Each task's duration is shown in both tabular and graphical format with grey cells indicating the time required to perform the action. A "float indicator" is shown immediately below each task to indicate the amount of time allotted before an action becomes unfeasible to complete. The green cells indicate that the action can be started anytime within this range and be completed successfully along with all its critical path predecessors. The orange cells indicate that less than 1 hour is available prior to the action becoming unfeasible. The red cells indicate if the action is not started prior to the event progressing into this range, that action is not anticipated to be successful. Light grey cells reflect performance of alternate success path activities.

The chart above the timeline graphically depicts the event progression with relation to WSE at the site. The base flow indicates normal water level conditions and the blue cells indicate WSE at a given time.

Critical elevations are depicted next to the WSE "ruler" and include descriptions. A resource chart is included below the timeline. This chart breaks down the different personnel required at the site during a flood event and indicates the number available at various skill levels. The loaded portion of the chart indicates the number of staff required for every given time slice.

The time line is based on the expected times for task completion. Time estimates have been validated by site exercises. Margins for completing actions may be ascertained by identifying the green bars in the Figure 5-1. Detailed discussion of feasibility and reliability of flood related actions are further discussed in Section 7.0. The work schedules were developed in accordance with 10CFR 26.205 (Reference 18) and it was determined that no exemptions will be needed. The SFMS building will remain accessible throughout the entire flood event duration, allowing periodic shift changes.

TABLE 5-1
Detailed Timeline of Scenario

Time (hr)	River Level	Action Identifier	Action	Procedure	Impact	Detailed Description Location or Evaluation
Scenario Initiation	890	-	Dam Break Occurs	-	-	-
0		PF-001	Dam operator notifies the site that the dam has failed.	AIA-001 "USACE and Utility Interface Document"	USACE monitoring engineer must notify the utility in accordance with agreement.	Section 7.4.1
0.5		PF-002	Site operators confirm river rise	AOP 1234A	Plant Staff Monitors River Levels Upstream of site and downstream of dam. Confirms increase in river level past setpoint XX.	Section 7.4.2
1		PF-003	Operators begin emergency shutdown procedure	AOP 1234A - Step X.X (requirement to begin shutdown) – EOP-1234A Steps X.X-X.X for shutdown	Plant will be shutdown in accordance with emergency shutdown procedure	Section 7.4.3
2		PF-004	Command and control transferred to Site Director	EPP 1234A Steps X.X-X.X	EPP-1234A "Severe Flooding (Reference 19) developed to respond	Section 7.4.X (Not provided in Example)

TABLE 5-1

Detailed Timeline of Scenario

Time (hr)	River Level	Action Identifier	Action	Procedure	Impact	Detailed Description Location or Evaluation
2		PF-005	Staffing levels determined	EPP 1234A Steps X.X-X.X	to this flooding event and the NTTF Rec. 9.2 EP (Reference 20)	Section 7.4.X (Not provided in Example)
2.5			Plant Reaches Hot Shutdown	EOP 1234A Step X.X (TS Req X.X)		
3		XF-001	Test SFMS DG-1&2 and connect to SFMS MCC	AOP 1234A Steps X.X-X.X		Section 7.4.4
		XF-002	Start SFMS DG-1	AOP 1234A Steps X.X-X.X		Section 7.4.X (Not provided in Example)
		XF-003	Test Submersible Pumps SFMS P-1,2, & 3	AOP 1234A Steps X.X-X.X		Section 7.4.X (Not provided in Example)
		XF-004	Stage and align Portable Pump SFMS P4 for make up to RCS and test	AOP 1234A Steps X.X-X.X		Section 7.4.X (Not provided in Example)
6			Place plant on shutdown cooling and continue to cool	AOP 1234A Steps X.X-X.X (TS Req XXX)	Plant will continue to cooldown in accordance with Plant Technical Specification (Reference 21) Req. XXX	
7			Plant Reaches Cold Shutdown	TS Req. XXX	Cooldown conditions are defined as RCS temp below 150F and pressure below 100 psia	
			RCS is borated to refueling concentrations	AOP 1234A Steps X.X-X.X		

TABLE 5-1

Detailed Timeline of Scenario

Time (hr)	River Level	Action Identifier	Action	Procedure	Impact	Detailed Description Location or Evaluation
10		XF-005	Open ADVs & Confirm Availability	AOP 1234A Steps X.X-X.X		Section 7.4.X (Not provided in Example)
		XF-006	Block Open ADVs to prevent closure	AOP 1234A Steps X.X-X.X		Section 7.4.X (Not provided in Example)
11		XF-007	Confirm ADVs Unavailable	AOP 1234A Steps X.X-X.X	Alternate Success Path Only if ADVs are Unavailable	Figure 6-2
		XF-007	Dispatch Crew to MSSVs	AOP 1234A Steps X.X-X.X		Figure 6-2
11.5		XF-007	Manually open MSSVs	AOP 1234A Steps X.X-X.X		Figure 6-2
12		XF-007	Confirm MSSVs are available Mechanically Prevent MSSVs from closing	AOP 1234A Steps X.X-X.X		Figure 6-2
21	<894	XF-008	Fully Staff SFMS	AOP 1234A Steps X.X-X.X	Essential personnel in SFMS building for duration of event	Section 7.4.X (Not provided in Example)
22	<894	XF-009	Disconnect plant from offsite power and remove power to components below 905 ft.	AOP 1234A Steps X.X-X.X (Flood Waters are predicted to exceed height of barriers within 8 hours)	Normal offsite power lost to station.	Section 7.4.X (Not provided in Example)

TABLE 5-1

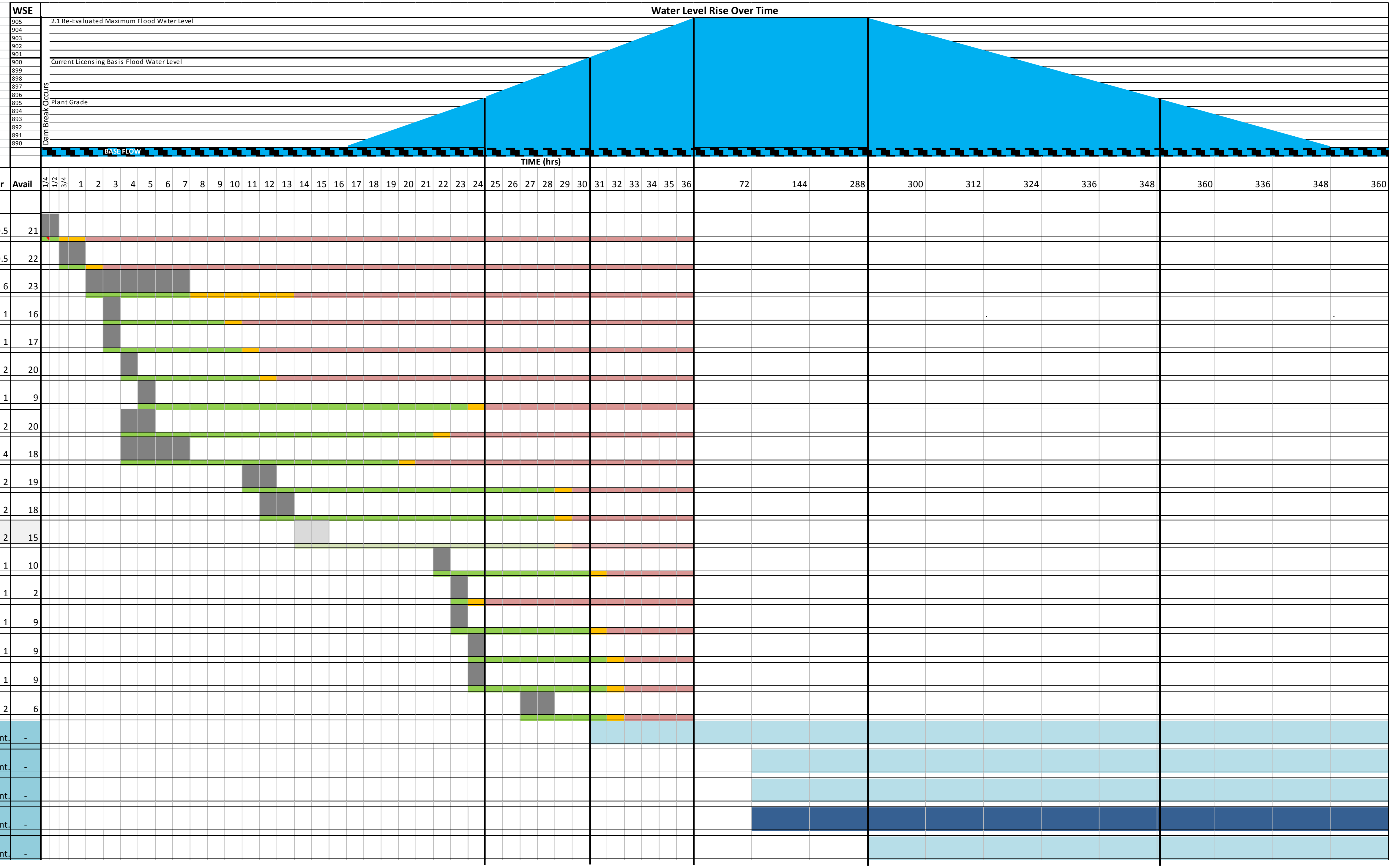
Detailed Timeline of Scenario

Time (hr)	River Level	Action Identifier	Action	Procedure	Impact	Detailed Description Location or Evaluation
		XF-0010	Open Manual Valves to connect SFMS P-1,2,3 well pumps to feedwater lines and RWST.	AOP 1234A Steps X.X-X.X		Section 7.4.X (Not provided in Example)
23	<894	XF-011	Start SFMS well pumps P-1 & 2	AOP 1234A Steps X.X-X.X		Section 7.4.X (Not provided in Example)
		XF-012	Start portable pump for RCS makeup	AOP 1234A Steps X.X-X.X		Section 7.4.X (Not provided in Example)
26	896	XF-013	RCS heats up to restore SG heat removal	AOP 1234A Steps X.X-X.X	RCS will heat up to allow sufficient heat transfer in the SGs. Decay heat will be removed by steaming through the ADVs.	Section 7.4.X (Not provided in Example)
30	900	XF-014	Operators maintain SG level, pressure and temperature	AOP 1234A Steps X.X-X.X	SG level will be monitored from dedicated SFMS Instrumentation Panel from the SFMS Building. Should instrumentation be lost, AOP-1234A directs operators to continue to provide makeup inventory to the SGs and maintain adequate decay heat removal.	Section 7.4.X (Not provided in Example)

TABLE 5-1
Detailed Timeline of Scenario

Time (hr)	River Level	Action Identifier	Action	Procedure	Impact	Detailed Description Location or Evaluation
36	905				Maximum WSE Reached	
72	905	XF-015	Refuel SFMS DG 1&2 every 12 hrs or as needed	AOP 1234A Steps X.X-X.X		Section 7.4.X (Not provided in Example)
		XF-016	Restaff and Change Shifts	AOP 1234A Steps X.X-X.X	Shift changes will occur in accordance with the work planned during PF-005. This will ensure reasonable work limits.	Section 7.4.X (Not provided in Example)
		XF-017	Regional Response Center Resources Available	AOP 1234A Steps X.X-X.X AIA-002 "RRC/NPP Agreement to Provide Resources Post Disaster or Accident" (Reference 22)		Agreement in Appendix X [Not provided in this example]
288	905	FRP-001	Site post-flood recovery procedure activated	Flood Recovery Plan FRP-001	Site flood recovery plan is initiated as water begins to recede	Section 7.4.X (Not provided in Example)
348	895		Flood water completely recedes from site			

Figure 5-1 - Scenario Timeline



ID	Task Names	Dur	Avail
-	DAM BREAK OCCURS		
PF-001	Dam Operator informs Station Personnel of Breach	0.5	21
PF-002	Operators Confirm River Rise	0.5	22
PF-003	Operators being emergency shutdown procedure	6	23
PF-004	Command and control transferred to Site Director	1	16
PF-005	Staffing levels determined and work planned	1	17
XF-001	Test SFMS DG-1&2	2	20
XF-002	Start SFMS DG-1	1	9
XF-003	Test SFMS Well Pumps P-1/2	2	20
XF-004	Stage and align portable pump for RCS make up	4	18
XF-005	Operators Open ADVs and confirm availablility	2	19
XF-006	Block open ADVs to prevent re-closure	2	18
XF-007	Open MSSVs and prevent re-closure	2	15
XF-008	Fully Staff SFMS Facility	1	10
XF-009	Remove power to equipment below max WSE	1	2
XF-010	Open manual valves to align SFMS pumps	1	9
XF-011	Start SFMS well pumps	1	9
XF-012	Start portable pump for RCS make up	1	9
XF-013	RCS heats up to restore SG heat removal	2	6
XF-014	Operators maintain SG level, pressure & temp	Cont.	-
XF-015	Operators refuel SFMS DGs	Cont.	-
XF-016	Restaff + change shifts	Cont.	-
XF-017	Regional Response Center Available	Cont.	-
FRP-001	Initiate post-flood recovery plan	Cont.	-

Timeline Legend

Green	More than 100% Time Margin available and within window to allow all predecessors to be completed
Orange	Less than 100% time margin available and within window to allow predecessors to be completed
Pink	Action (or its predecessors) cannot be completed in time available if started within this timeframe
Light blue	Long Term Repeatable Actions

TABLE 5-2

RESOURCE LOADING FOR ENTIRE FLOOD DURATION

TIMELINE		1/4	1/2	3/4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	72	144	288	300	312	324	336	348	360	336	348	360
RESOURCES	Avail	REQUIRED																																																		
Senior Reactor Operator	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Critical		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Non-Critical		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Reactor Operator	17	6	6	6	6	6	6	6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Critical		3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Non-Critical		3	3	3	3	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mechanical Maintenance - Super	9	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	4	4	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Critical		2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Non-Critical		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mechanical Maintenance - Craft	67	28	28	28	28	28	28	28	28	28	10	10	10	10	10	10	10	14	14	14	16	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Critical		18	18	18	18	18	18	18	18	18	8	8	8	8	8	8	8	12	12	12	14	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Non-Critical		10	10	10	10	10	10	10	10	10	2	2	2	2	2	2	2	4	4	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Electrical Maintenance - Super	8	4	4	4	4	4	4	4	3	3	2	2	2	2	2	2	2	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Critical		3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Non-Critical		1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electrical Maintenance - Craft	34	18	18	18	18	18	18	18	18	14	6	6	6	6	6	6	6	12	12	12	12	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Critical		14	14	14	14	14	14	14	14	12	4	4	4	4	4	4	4	10	10	10	10	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Non-Critical		4	4	4	4	4	4	4	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Equipment Operator	9	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Critical		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Non-Critical		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Note: This table intends to demostrate the total number of personnel available and required for all activities proposed during the flood event, not just resources for flood specific activities

6.0 Scenario Success Path Progression

-- Preparer's Note --

The objective of the scenario-based evaluation is to demonstrate that there is high confidence that key safety functions can be maintained during the reevaluated flood hazard. The process is required to be systematic, rigorous and conservative. To accomplish this task, a success path for the scenario has been developed to illustrate the key components that must change state, operator actions required to carry out the strategy and flow paths to show the progression of the actions for the flood event duration. This success path has been developed to satisfy the requirement for "logic structures" as the goal is to conservatively demonstrate a highly reliable strategy for the key steps in the overall flood mitigation strategy. This section should tie the entire analysis together and include pointers to the locations of the detailed analysis justifying the conclusions drawn in this section.

The following discussion focuses only on strategies associated with mitigating extreme flood hazards under conditions where the RCS is intact. Adjustments to these strategies may be necessary to address external flooding mitigation during other modes of operation (e.g., refueling). Additional strategies will also be required to describe actions taken to maintain spent fuel pool cooling and inventory.

Note that this example focuses on an illustration of discussion on mitigation strategies for an external flood scenario with emphasis on describing the success path and one simple recovery action. In developing external flood mitigation strategies, plants should consider consequences of failure of equipment and/or implementation actions and consider the appropriateness of reasonable back-up mitigation strategies.

-- -------------------- --

This section provides an overview of the plant flood mitigation strategy and its role in ensuring that the key plant safety functions are retained for the duration of the flood event. Maintaining the following five safety functions will ensure the integrity of the fission product barriers and keep the core in a cool, stable state. Each function has a detailed discussion on its role and the steps required to successfully implement the strategy. A success path (Figure 6-1) has been developed to visually represent the required elements for the strategy to be carried out successfully. Each element represented in the strategy is described in greater detail in Table 6-1 and the location of detailed analysis supporting the conclusions is contained for each element in Figure 6-1.

6.1 Key Plant Safety Functions

The primary focus of flood protection and mitigation strategies is to ensure that the plant can be placed in a safe stable state throughout the duration of the flood event. A review of all relevant plant safety functions has been performed. Based on that review the plant has determined that the key safety functions to be ensured are:

- Reactivity control
- Reactor inventory control
- Decay heat removal
- Reactor Pressure control
- Containment Integrity

6.1.1 Reactivity Control

The advance notice available prior to the flood reaching the site enables the plant staff to conduct an orderly emergency shutdown without reliance on abnormal operating procedures. Operators will follow plant procedure EOP-1234A “Reactor Shutdown” (Reference 24) to insert control rods, stopping the chain reaction and using the shutdown cooling system to decrease the temperature of the RCS. Inventory make up will be provided using the station’s normal charging pump and boron will be added, as directed in the procedure. All of these actions will be completed well in advance of the floodwaters reaching the site.

The plant will be maintained in a cooled condition (RCS temperatures less than 250 F) throughout the entire flood event duration and at that temperature RCP seal integrity is expected. Although the need for make-up is unlikely, the strategy includes the potential for direct RCS make-up using the submersible pump, SFMS P4. It is staged in the bottom of the auxiliary building with pre-aligned piping to allow installation of the pump prior to the room being flooded and to allow direct injection from the RWST into the RCS (See Section 3). To ensure reactivity control is maintained, any make-up to the RCS will be made using borated water. Prior to the onset of the flood event the initial RWST inventory will be filled with borated water and maintained towards the upper band of the Technical Specification Maximum Level. The initial RWST inventory has been evaluated to be adequate to make-up RCS leakage for a period in excess of 200 days (reference 9). Unborated makeup may be supplied at a rate in excess of the RCS boil-off rate. Should additional inventory be required in the long term, provisions have been made with the Regional Resource Center to provide a mobile boration unit.

6.1.2 Reactor Inventory Control

In an analogous fashion to reactivity control, RCS inventory control is addressed in two phases. The early phase response relies on injection from the RCS charging system. As low temperature operation associated with the RCS cooldown strategy also provides a high degree of confidence that RCP seals remain integral (See Reference 9), no RCS inventory loss is anticipated during the flood scenario. Prior to the flood reaching the site, inventory is added to the RCS to accommodate shrinkage of the RCS inventory during plant cooldown. This process follows plant procedure EOP 1234A “Reactor Shutdown” (Reference 24) and all equipment is available throughout the shutdown. As stated above, the RCS temperature and pressure is expected to be low enough that RCP seal leakage is considered negligible. An assessment of seal elastomer performance is provided in Reference 9 and under the post-flood operational conditions it indicates that upper stage elastomers will be capable of ensuring seal integrity for the flood event duration. As a precaution, the plant flood program plans to accommodate potential

RCS inventory loss, via inventory makeup is provided by SFMS P4. This pump has been sized such that it is capable of delivering borated water to a depressurized RCS at rates in excess of that possible from a single RCP seal failure. Details on the pump capabilities are provided in Sections 3 and 4. Inventory levels in the RCS are monitored by reference to the pressurizer level.

6.1.3 Decay Heat Removal

The most important function of the SFMS is to ensure that heat may be reliably removed from the core and the RCS for the duration of the flood event. Early in the event, prior to the arrival of floodwaters at the site, heat removal from the RCS proceeds using normally available decay heat removal systems. To establish desired plant shutdown conditions, the RCS is placed on shutdown cooling and the RCS temperature is decreased to the point where heat may be removed by a depressurized steam generator. Once the plant is in a stable shutdown condition and the RCS temperature decreasing, the plant staff will focus on depressurizing the SGs to atmospheric conditions. Flood response procedure (AOP-1234A) provides instructions for the operator to depressurize the SGs via use of the atmospheric dump valves and block the valves open via use of a mechanical device (MD-1). During this preparatory phase, lost SG inventory is replenished via the auxiliary feedwater system via water from the condensate storage tank. Plant operators are instructed to establish steam generator liquid levels at the upper band on narrow range steam generator level instrumentation (available within the MCR and SFMS building). In accordance with the procedure AOP-1234A, the SG inventory makeup responsibility will be transitioned from the AFW system to either of the SFMS Pumps with suction from well water (pumps are redundant). The plant will continue to remove decay heat with one of these pumps for the duration of the flood event. The well pump injection piping includes flow control valves which may be remotely adjusted from the SFMS building by the operating staff. Prior to arrival of the floodwaters AOP-1234A instructs the operator to turn off the SDC system, monitor the RCS temperature and adjust the flow control valve using the SFMS system to maintain a constant SG level (indicative of a balance between decay heat removal and SG steam release). Operators are instructed to expect a gradual plant heat-up and stabilize the RCS temperature below a temperature of 250 F. This temperature is chosen so that the operators can establish adequate decay heat removal while ensuring RCP seals (a potential cause of RCS inventory loss) will retain their integrity with adequate margin throughout the entire flood event duration. These operational temperatures have been confirmed by analysis (Reference 9). Minor deviations from this target are not expected to have a significant impact on event mitigation as the RCS pressure will be low and as a result of ambient heat loses to the containment, temperature of the elastomers in the upper seal stages are will be substantially cooler than the RCS fluid.

Flow control valves are included in the SFMS design to allow operators some control of the RCS cooling process; however they are not considered critical to the overall SFMS function. To ensure a successful event outcome, the flow control valves are designed to fail in the “as is” condition. While operation of the flow control valves periodically during the flood event is desirable, the impact of valve failure would be, over time, to increase the quality of the steam generator discharge. To accommodate the resultant liquid carryover into the main steamlines, several liquid drains located at various locations along the bottom of the main steamline were are maintained in the open condition. Assuming a balance flow condition at one day following shutdown, and a constant flow rate to the SGs, the exit steam generator mixture quality after two weeks would be ~0.5 and 0.25 after 6 months. Should liquid accumulate in the steam line, static structural analyses indicate the piping and supports are capable of supporting the potential loading.

Adequate decay heat removal is indirectly assessed via monitoring pressurizer and SG levels. As the SG is intended to be operated in a saturated depressurized condition, tracking of SG temperature is not very informative. RCS hot leg temperatures are initially monitored in the control room during the initial plant cooldown. Once the SFMS has been actuated RCS temperature would be expected to increase until equilibrium is reached between the RCS and SG. Analyses suggest that during these conditions natural circulation temperature differentials are on the order of 10-20 ^{o}F. As pressure drops in the steam discharge piping is expected to be no larger than several psi, the expected post-flood RCS temperature and pressure would be less than 250^{o}F and 40 psia respectively. At these operating conditions RCP seal elastomers have no significant environmental challenge (see reference 9 and 12 for further details and analysis).

6.1.4 Reactor Pressure Control

Reactor pressure control is identified as a key safety function in Reference 1. This function is implicitly met by satisfying reactivity control and the RCS heat removal safety functions. In the context of the long term operational state maintaining the RCS pressure low provides additional margin to leaks from the RCS. Reactor pressure, along with other RCS attributes is directly monitored in the SFMS building. Thermal hydraulic analyses (Reference 12) demonstrate plant mitigation strategies can effectively maintain the desired RCS conditions provided RCS leakage is controlled and well pumps remain operational.

6.1.5 Containment Integrity

Prior to the onset of flooding AOP-1234A instructs the operator to ensure the containment is closed with only penetrations involved in maintaining and monitoring plant safety functions active. While containment pressure is monitored in the SFMS building no on-site provisions are available to actively reduce containment pressure using containment sprays or fan coolers. As long as the RCS remains cooled and inventory losses are restricted to identified leakage, no challenge to containment integrity is expected throughout the flood event duration. Should containment heat removal be required later in the scenario, connections points for portable equipment to tie into these systems have been identified.

6.2 Plant Operational States during the Flood Event

The strategy discussed in this integrated assessment will initially perform an emergency plant shutdown taking the plant from full power to shutdown cooling entry conditions. Once in shutdown cooling the plant will continue with the cooldown until the RCS reaches approximately 150^{o}F at an RCS pressure of about 100 psia. The pressurizer level will be maintained half full. Component cooling water will also be maintained to ensure RCP and associated seals are well cooled. This state will be maintained until the operators are instructed (AOP-1234A) to transition from shutdown cooling heat removal to reliance on the steam generators.

At the time of transition to SG cooling the SG inventory has been fully established and the steam generator has been depressurized and cooled to about 150^{o}F. In addition, the RWST is maintained to maximum TS levels and maximum boron concentration.

6.3 Scenario Success Path

Figure 6-1 contains all the key steps in the success of the flood mitigation strategy. It includes operator actions and key equipment necessary to perform and maintain the plant key safety functions for the entire duration of the event. Each element has detailed calculations in Sections 7 and 8 to document the conclusion for high reliability of components and operator actions, respectively. All the success path items correspond to the actions on the timeline in Figure 5-1.

The information in Figure 6-1 is presented in the form of a logical success path. It shows the key actions and systems that are required to carry out the flood mitigation strategy. Each item has been shown to be feasible and reliable, with margin. Based on time and resources available, all actions have greater than twice the amount of time required to complete the action in the scenario (see Figure 5-1 and Section 7). The components used in each system have had a systematic, rigorous and conservative evaluation of their reliability (See Section 4). The actions are well proceduralized, trained and executed periodically giving a high confidence that they can be carried out as intended within the timeframe required (see Section 7). Therefore, the conclusion can be made that success path shown is highly reliable in maintaining key safety functions for the entire flood even duration and the strategy can be implemented to protect the plant from a flood hazard as defined in this scenario.

In the event that the ADVs fail to open, an alternate strategy for providing depressurization and steam removal has been provided in Section 6.4.

Table 6-1 will describe in greater detail the information each success path element represents.

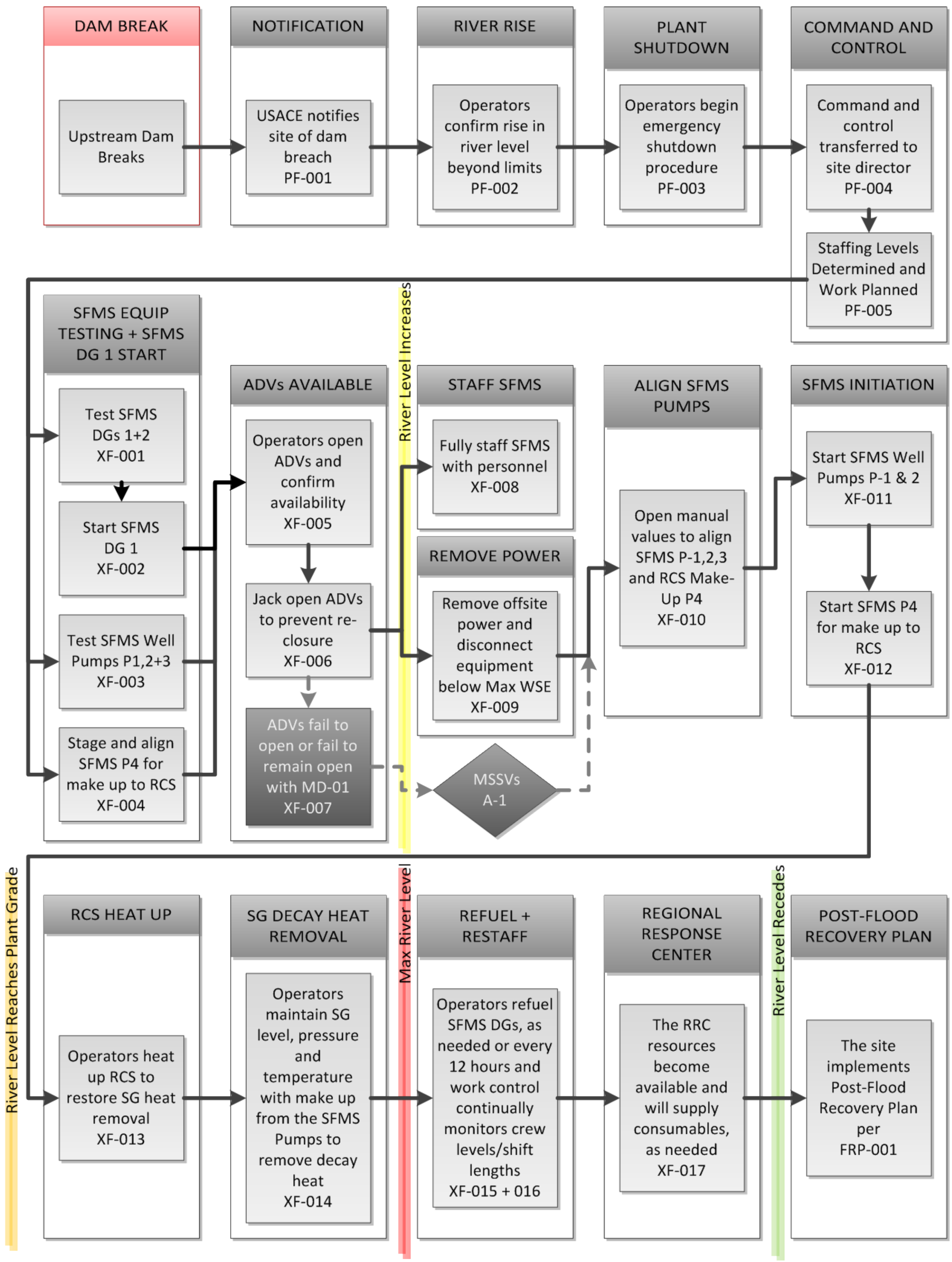
Table 6-1
Success Path Element Description

Success Path Element	Description
Dam Break	Event Occurs
Notification	USACE notifies site of dam breach in accordance with procedure (AOP-1234A) and agreement AIA-001.
River Rise	Operators will monitor several locations downstream of the dam and upstream of the site. Entry conditions and trigger points are found in AOP-1234A Steps X.X
Plant Shutdown	Operators begin to shutdown the reactor when entry conditions are realized. The shutdown will begin and finish well in advance of the flood waters, therefore normal plant operating procedures will be used to guide the shutdown.
Command and Control	Upon notification of the dam break, confirmation of the river rise and shutting the plant down, control of operations will be transferred to the site director to carry out the steps of AOP 1234A. Staffing levels will be determined and work will be planned to allow all tasks to be done within the timeframe.
SFMS Equip Testing + SFMS DG 1 Start	Operators will test the SFMS DG 1 & 2, and the well pumps SFMS P 1, 2 & 3. The portable high pressure SFMS P4 will be staged in the Aux Bldg and connected, as directed in AOP-1234A in accordance with Figure 3-4. No valves will be opened at this time.

Table 6-1
Success Path Element Description

Success Path Element	Description
ADVs Available	Operators will fully open the ADVs and confirm they are available for decay heat removal. The ADVs will then be jacked open with MD-1 to prevent their closure throughout the entire event.
ADVs Fail	In the unlikely event that the ADVs fail to open using IA or fail while attempting to mechanically prevent their closure, an alternate success path (A-1) to depressurize the SG and remove steam is provided in Figure 6-2 and Table 6-2.
Staff SFMS	Site director will order the SFMS be fully staffed and prepared for the event prior to the arrival of flood waters.
Remove Power	Power will be removed from all equipment below the maximum WSE. Procedural guidance is provided in AOP-1234A Encl XXX to direct specific equipment items to be removed from service.
Align SFMS Pumps	Operators will open valves required to align the SFMS P 1, 2, 3 & 4 in accordance with AOP-1234ASteps X.X. Valves are shown on Figure 3-4.
SFMS Initiation	The SFMS equipment will be placed into service. Operators will start the SFMS DG 1&2 and load the SFMS MCC. The SFMS P 1, 2, 3 & 4 will be started and made available for makeup. Procedure AOP-1234A Steps X.X will be used to perform the SFMS initiation.
RCS Heat Up	Operators will follow AOP-1234A Steps X.X to allow the RCS to heat up to 250F. Once the minimum temperature is reached, decay heat removal will be restored through the steam generators.
SG Decay Heat Removal	Decay heat will be removed from the RCS by maintaining the level, pressure and temperature as directed in AOP-1234A Steps X.X. Make up will be provided to the primary and secondary side, as required, through the SFMS Pumps.
Refuel + Restaff	Consumables will be replenished for the entire flood event duration. The diesel generator fuel oil tank will be refilled, at least every 12 hours. Resources, work load and shift lengths will be monitored by the site director and MCR to ensure compliance with 10 CFR26.205. This will place the plant in a safe stable state.
Regional Response Center	The RRC will be staffed and fully available prior to the flood waters receding from the site. Agreement AIA-002 in Appendix X (Reference 22) outlines the responsibilities and capabilities of the RRC. This includes provisions for additional staff, technical support, equipment and consumables.
Post-Flood Recovery Plan (FRP)	After flood waters recede, the site will implement the post-flood recovery plan. The details of this plan are contained within FRP-001 (Reference 23).

Figure 6-1 – Scenario Success Path



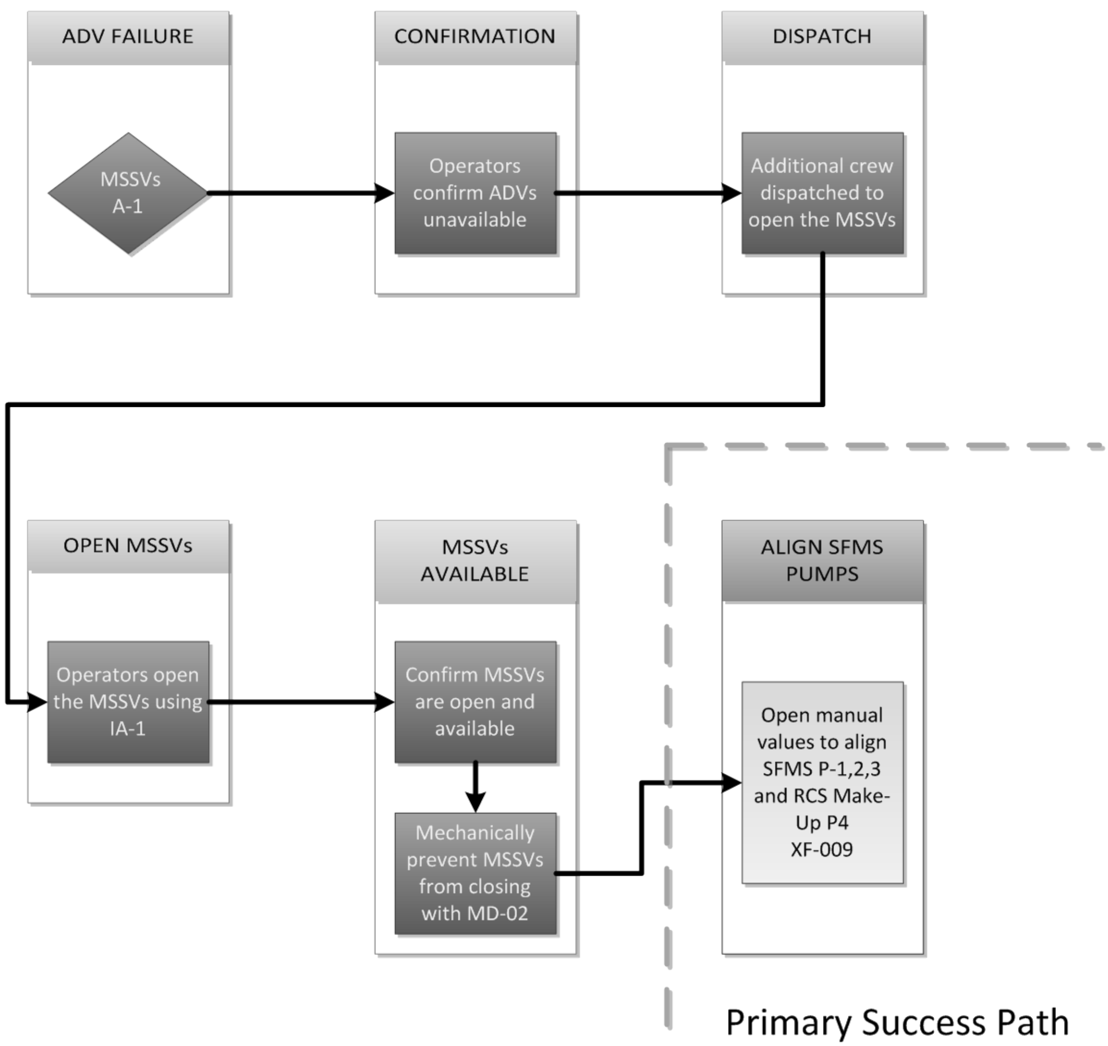
6.4 Alternate Success Path for Depressurization and Steam Release

An alternate strategy for SG depressurization and steam removal has been developed in the unlikely event that the ADVs fail to open or fail to remain open with the mechanical device (MD-01). The MSSVs have been identified as another means to depressurize and reject steam to the atmosphere. The actions and details for the strategy can be found below in Table and Figure 6-2. As this is an alternate strategy to the highly reliable primary success path shown in Figure 6-1, the actions will only be addressed in the timeline to confirm that the strategy is feasible. Additional details on the implementation can be found in AOP-1234A Steps X.X. This strategy is periodically trained on an annual basis.

Table 6-2
Success Path Element Description

Success Path Element	Description
ADV Failure	ADVs are not available for SG depressurization and steam rejection
Confirmation	Operators confirm that the ADVs are not available
Dispatch	Dispatch an additional crew to the MSSVs
Open MSSVs	Operators open the MSSVs by manipulating the manual valves
MSSVs Available	Operators confirm that the MSSVs are open and available for steam rejection. The MSSVs will then be prevented from closing using a mechanical device (MD-02)
Align SFMS Pumps	The alternate success path then merges with the primary success path.

Figure 6-2 – Alternate Success Path (A-1)
Depressurization and Steam Release



6.5 Event Tree Logic

To clarify the impact of the actions on event success the scenario is cast in the form of an event tree. As actions are considered feasible and reliable, operational failures of equipment were primarily selected to illustrate failure branches. For simplicity of presentation, failure branches with highly reliable recoveries/proceduralized back-up plans are explicitly included. In this scenario, the developed failure branch occurs following the inability of the plant staff to create a steam release path using an ADV. A proceduralized back-up action to jack open the MSSVs is included in the event tree. Other "failure" branches are noted as potential low probability events but for the sake of clarity are not further developed. Top events on the event tree presented in Figure 6-3 are summarized below. A summary of the top events and success criteria are provided in Table 6-3 discussion of low probability end states is provided in Table 6-4.

Table 6-2
Summary of Top Events

Top Event	Description
Dam Break Occurs	Initiating Event
Pre Flood Activities	The plant receives notification from the USACE that the upstream dam has breached. The site will enter into AOP-1234A, confirm that the river level upstream is rising and transfer command and control to the site director to determine staffing/work load. This top event includes actions: PF-001, 002, 004 & 005. Detailed justification for high reliability and margin can be found in Sections 8 & 9.
Plant Shutdown	Operators will perform an emergency shutdown in accordance with AOP-1234A. This action will be performed well in advance of the flood waters arriving with nominal PSFs. This step includes action: PF-003
SFMS Test & Align	SFMSDGs and P-1, 2, 3 & 4 will be confirmed available in accordance with AOP-1234A. Operators will test and align the equipment as detailed in AOP-1234A. This top event includes actions: XF-001,002 & 003.
ADVs Available	The ADVs are opened under normal operating conditions with all normally available equipment well in advance of the flood waters arriving. Once the ADVs are confirmed open the operators will mechanically prevent its closure with a specially designed device MD-01 creating a permanent way to reject steam to the atmosphere. This event includes actions: XF-004 & XF-005
MSSVs Available	In the unlikely event that the ADVs are not able to be opened or prevented from reclosing, the MSSVs will be opened to create an alternate path for steam rejection and secondary side heat removal. This action has a success path developed in MSSVs A-1, but no detailed calculation have been provided. The steps are directed in AOP-1234A
SFMS Start	Prior to the flood waters reaching the site, the SFMS system will be placed into service. The SFMS DGs will provide power and the SFMS P-1, 2, 3 & 4 will provide water in accordance with the description in Section 3. This event includes actions: XF-008, 009, 010 & 011.
SG DHR	When normal plant equipment is lost due to the flood barriers being overtopped at 900', decay heat removal will need to be transferred to the SG from the DHR system. Operators will increase the RCS temperature to 250F to re-establish heat removal through the SGs. From there, SG level, temperature

Table 6-2 Summary of Top Events	
Top Event	**Description**
	and pressure will be monitored to continue to remove decay heat for the entire flood event duration. This event includes actions: XF-012 & 013
Safe Stable State	As the SFMS continues to remove decay heat, the only dependency will be diesel fuel oil and operators to monitor the SG parameters. AOP-1234A directs the SFMS DGs to be refueled when needed or every 12 hours. The site director will continue to plan work and monitor shift lengths to provide operators the appropriate work load. Once the flood waters recede the RRC and post flood procedure will be implemented. This event includes actions: XF-014, 015, 016 & 017.

Table 6-3
Summary of Top Events

Top Event	Description
Dam Break Occurs	Initiating Event
Pre Flood Activities	The plant receives notification from the USACE that the upstream dam has breached. The site will enter into AOP-1234A, confirm that the river level upstream is rising and transfer command and control to the site director to determine staffing/work load. This top event includes actions: PF-001, 002, 004 & 005.
Plant Shutdown	Operators will perform an emergency shutdown in accordance with EOP-1234A. This action will be performed well in advance of the flood waters arriving with nominal PSFs. This step includes action: PF-003
SFMS Test & SFMS DG 1 Start	SFMS DGs and P-1, 2, 3 & 4 will be confirmed available in accordance with AOP-1234A. Operators will test and align the equipment as detailed in AOP-1234A. After testing, the SFMS DG 1 will be placed into operation. This top event includes actions: XF-001,002, 003, & 004.
ADVs Available	The ADVs are opened under normal operating conditions with all normally available equipment well in advance of the flood waters arriving. Once the ADVs are confirmed open the operators will mechanically prevent its closure with a specially designed device MD-01 creating a permanent way to reject steam to the atmosphere. This event includes actions: XF-005 & XF-006
MSSVs Available	In the unlikely event that the ADVs are not able to be opened or prevented from reclosing, the MSSVs will be opened to create an alternate path for steam rejection and secondary side heat removal. This action has a success path developed in MSSVs A-1, but no detailed calculation have been provided. The steps are directed in AOP-1234A. Includes XF-007.
SFMS Start	Prior to the flood waters reaching the site, the SFMS system will be placed into service. The SFMS DGs will provide power and the SFMS P-1, 2, 3 & 4 will provide water in accordance with the description in Section 3. This event includes actions: XF-010, 011 & 012.
SG DHR	When normal plant equipment is lost due to the flood barriers being overtopped at 900’, decay heat removal will need to be transferred to the SG from the DHR system. Operators will increase the RCS temperature to 250F to

Table 6-3
Summary of Top Events

Top Event	Description
	re-establish heat removal through the SGs. From there, SG level, temperature and pressure will be monitored to continue to remove decay heat for the entire flood event duration. This event includes actions: XF-013 & 014
Safe Stable State	As the SFMS continues to remove decay heat, the only dependency will be diesel fuel oil and operators to monitor the SG parameters. AOP-1234A directs the SFMS DGs to be refueled when needed or every 12 hours. The site director will continue to plan work and monitor shift lengths to provide operators the appropriate work load. Once the flood waters recede the RRC and post flood procedure will be implemented. This event includes actions: XF-015, 016, 017 & FRP-001.

Table 6-4
Summary of Low Probability End States

End State	Description of End State	Justification of Low Probability
ES-001	Successful end state. All events in the scenario success path were executed successfully.	Not applicable-Success State
ES-002	This end state indicates early responses to the flood scenario are successful, however in the long term failures emerge in the basic strategy and RRC resources are inadequate to restore cooling in a timely fashion.	This is a low likelihood end state. Redundant power sources and pumps included in the SFMS will provide reliable performance for the duration of the flood event. At three days into the event the RRC is available to supplement plant capabilities and back-up random equipment failures. This support can include additional manpower, fuel resources and back-up equipment. Appropriate connections have been established for use of this equipment in a manner consistent with the plant mitigation strategy. These recovery actions are not developed in this logic tree.
ES-003	This sequence represents operator failure to maintain level and pressure in the steam generators or failure to recognize the need for make up to the RCS. This sequence assumes that all equipment is functional and working.	This end-state has been determined low likelihood. Procedures are well written and established to provide operators with the guidance they need to maintain level and pressure in the SGs. Operators are trained to recognize the need for RCS make up and have well written procedures to implement a strategy.
ES-004	This end state represents the inability of operators to start all the SFMS equipment and keep it running, when needed. The equipment includes all equipment listed in Table 4-1, except the ADVs and MSSVs.	This is a highly unlikely sequence. All the equipment is well maintained within a program as equipment important to safety. The SFMS DG 1&2 and SMFS P-1&2 are redundant. Fuel is stored on site and agreements to ensure continuous fuel supply are in place. Adequate time margin exists to allow for repairs of alternate strategies, should a piece of equipment fail to perform its function.
ES-005 through ES-008	These end states are analogous to ES-001 through ES-004, with the exception that steam generator steam relief is accomplished via the MSSV path as opposed to the ADV.	Discussions provided above for ES-001 through ES-004 apply to respectively to statuses-005 through 008
ES-009	The flood mitigation strategy fails as a result of inability to	Both actions are highly reliable and either action has a high

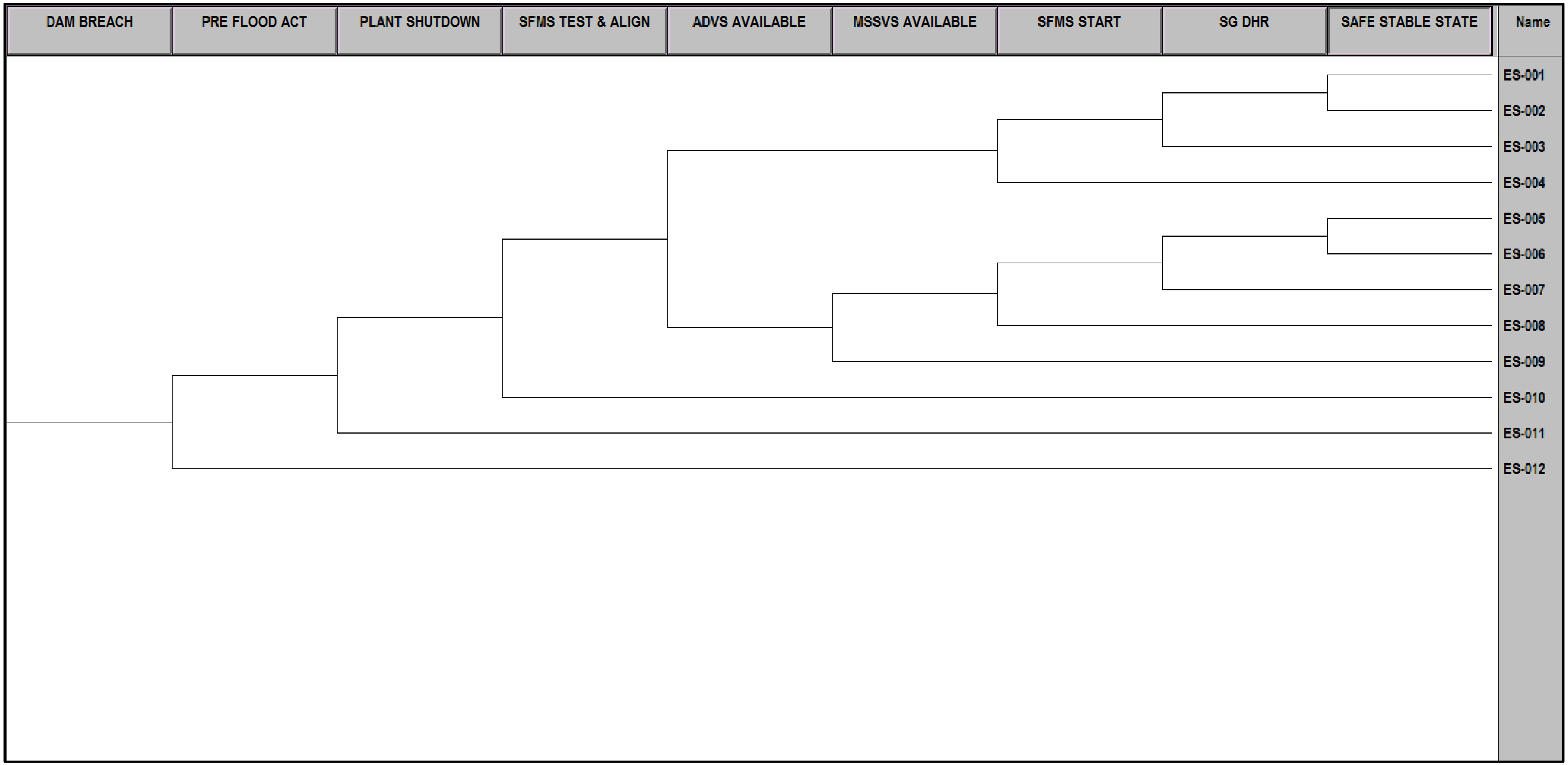
Table 6-4
Summary of Low Probability End States

End State	Description of End State	Justification of Low Probability
	establish a steam release path from the steam generator. This end state represents the failure of opening the MSSVs following the failure to open the ADVs.	probability of success. They will take place well in advance of the flood reaching the site. ADV actions involve normally available operational equipment and time to perform action is small fraction compared to the time available (See Section 7). The MSSV action is well proceduralized, trained upon and all necessary equipment to open the MSSVs is available to the operators before the flood. The redundancy in two separate paths to release steam to the atmosphere makes this end state very unlikely.
ES-010	The sequence represents the failure to test and align the SFMS equipment. This includes not dispatching a crew to the SFMS building in a timely manner, inability to correctly align AC power and SFMS Pumps or failure to run of the SFMS DGs and P-1-4.	This is considered a very unlikely end state as the SFMS and associated flood mitigation components are considered important to safety and placed in appropriate preventive/corrective maintenance, surveillance and testing programs to ensure that these systems will be available when called upon. The facility is in a secure and environmentally protected environment. In addition, an adequate supply of parts and trained maintenance personnel are available on site to perform most repairs. The actual time to perform action is very short (under 30 minutes) and very well trained. Available time to perform action is expected to exceed 4 hours. Short term fuel supply is readily established via opening of fuel oil day tank shut-off valves and gravity feed to the SFMS DGs. On-site refill of the day tank may be accomplished via refill of the fuel oil transfer pump or direct refill via oil tanks. Procedures to contact suppliers and procurement agreements are in place. Suppliers have been selected based on ability to reach SFMS building site during a flood and regional fuel resources are

Table 6-4
Summary of Low Probability End States

End State	Description of End State	Justification of Low Probability
		expected to be adequate based on traditional stored supply in region. A large 10,000 gal. quantity of available fuel on site provides a significant time buffer (margin) to accommodate delivery delays. A helipad is also available on site to support.
ES-011	This end state implies that the post flood action failed because the plant staff could not maneuver the plant to a cold shutdown condition.	This end state is not considered credible. This action occurs well in advance of the flood reaching the site. Shutdown action is performed periodically and is frequently a subject of training. Once the operators are notified to place the plant in cold shutdown the action to perform the shutdown is highly reliable. Time to plant shutdown is ample and all equipment used will be well within their design parameters.
ES-012	This end state is driven by USACE not notifying site of the impending hazard or the utility not activating the severe flood response plan in a timely manner.	This end state is considered incredible. The USACE monitors dams to ensure their integrity. Re-evaluation results are based on dam failure USACE directly contacts plant management and control room. Once notified utility will follow standard emergency procedures. Time required to perform action is short (several minutes) and available margin is many hours (See Section 7). Sunny day dam failure without limiting antecedent and concurrent conditions will not result in flood level exceeding 905 ft.

Figure 6-3: Scenario Event Tree



7.0 Evaluation of Manual Action

-- Preparer's Note --

The intent of this section is to provide selected examples of those manual actions and groups of actions identified in Section 6. Section 7.4 of this example includes detailed evaluations for 3 identified flood specific manual actions: PF-001, PF-002 and XF-001. In addition, a representative treatment of a standard plant action (emergency shutdown) is also included: PF-003. All other actions will not be evaluated in this example; however, the licensee would be expected to evaluate all flood specific actions in detail.

The focus of the manual action assessment for the scenario example is to evaluate human actions unique to mitigation of an external flood. Therefore, standard operator actions included in the traditional emergency response procedure (such as PF-003) need only be assessed to address their impact on the timeline, and assure that the action is not "informed" by the external factors surrounding the event. Plant experience in performing those actions successfully in the past may be used to confirm that the actions may be completed in the desired time window. As discussed in the ISG, standard proceduralized actions associated with performing an emergency cooldown/shutdown are considered highly reliable and regulated under separate plant processes. The actions should be reviewed with respect to timing, access and other pertinent flood conditions, but the reliability of normally performed actions need not be further evaluated. Flood specific actions would require additional scrutiny and actions should be validated separately.

Manual actions are to be evaluated in accordance with Appendix C of the ISG. The goal of the manual action evaluation is to demonstrate that actions credited in the scenario success path progression are both feasible and reliable. Consistent with Appendix C, feasibility is demonstrated by showing (1) performance shaping factors (PSFs) associated with stress are nominal or moderate, (2) all other PSFs are nominal and (3) the time available to perform action is greater than the time required, when accounting for uncertainties. Event trees may be used to identify potential errors, error detection methods, and error recovery paths for the purpose of determining the adequacy of the margin. A simplified alternative criterion for determining if the margin is adequate to deem an action as reliable is to establish that the margin is not less than 100%. Such a margin may be justified when recovery from an error in performing the action could be accomplished by restarting the task from the beginning. The basis for the specific time margin used in the analysis should be justified and documented.

Performance shaping factors that contribute to degraded performance should be addressed and information provided to demonstrate that these degraded factors will not result in the inability of the action to be successfully completed. The overall conclusion from this evaluation should demonstrate that the mitigation actions stipulated can be accomplished (are feasible) and have adequate margin to account for unforeseen circumstances or recovery from error (are reliable).

7.1 Introduction

This section describes the evaluation of manual actions performed to support this scenario within the integrated assessment (IA). The primary intent of this section is to evaluate the constituent actions comprising the flood mitigation strategy identified in Section 6. Each action included in the strategy is evaluated in accordance with the guidance provided in JLD-ISG-12-05 Appendix C. Actions assessments consider the specifics of the elements in each action, as well as, the interfaces with other actions taken by the individual. Action dependency will be evaluated with respect to the predecessor or successor. The ability to perform the various actions, alone or in concert, was reviewed considering staffing availability and competing activities.

The remainder of this section is divided as follows: Section 7.2 will include the identification of all critical actions for required for successful mitigation of the scenario. A summary of the results of the evaluation will be included for easy reference. Section 7.3 will discuss the methodologies used to perform the detailed evaluations in Section 7.4.

7.2 Summary of Administrative and Operator Actions Conclusions

As discussed in the previous sections, the site cannot protect normally installed plant safety equipment during a flooding event. Mitigation of the effects will be the primary goal of the operators throughout the scenario progression. The site will receive warning that the upstream dam has failed and begin taking mitigation actions accordingly. Once preparatory steps have been taken, the station personnel will await flood waters to inundate the site. The SFMS will be started prior to overtopping of the flood barriers. Once started the SFMS will be used to maintain key safety functions (KSFs) indefinitely or until such a time when the SFMS may be transitioned to an alternate more permanent system.

The overall conclusion of the Manual Action Evaluation (MAE) was that all actions comprising the flood mitigating strategy were both feasible and reliable. The PSFs associated with most actions were concluded to be nominal. Where PSFs were expected to be degraded, adequate planning and processes are in place to ensure actions may be effectively executed. Overall, lines of responsibility are clear, and operator actions are included in procedures that are written in accordance standard site procedure writing guidelines. For site controlled procedures, operating and maintenance staff are trained in the respective procedures following INPO training guidelines. Procedures are maintained current.

Procedures of interfacing organizations are conducted per their organization and state requirements. Site staff located at the dam, and responsible for implementing emergency contact procedures, are instructed on emergency contact procedures upon being stationed at the site. During times associated with potential dam distress the dam operations staff is placed on a high alert status.

To assess operator action task completion times, the evaluation team used a combination of plant experience, operators' interviews, table-top exercises and actual plant drills including reasonable simulations of many of the actions under consideration. Timing values used in the timing assessment were selected as bounding values from plant records (e.g. results of Time –Critical-Action-Program assessments) and increased as necessary to account for the impact of perceived workload or stress. Using bounding values to estimate required action times, timing analysis indicated that all the actions are both feasible and reliable. The resulting time margin assessments indicates that all required manual actions have time margins from 75% to over 100% the bounding required time estimate. The JLD-ISG-2012-05 notes that “one acceptable method for assessing the adequacy of the time margin is to establish that the time margin is equal to or greater than the maximum recovery time for any single credible human error.” . Adequate manpower is available at the site and actions to waive work rule requirements have been previously submitted to, and approved by NRC for the entire flood event duration. Detailed manpower loading strategy is contained in Section 5. The actions were evaluated using the guidance in JLD-ISG-2012-05 and detailed evaluations can be found in Section 7.4.

Table 7-1
Summary of Operator Actions Evaluated in Dam Breach Scenario

Action ID	Task Names	Feasible	Reliable
PF-001	Dam Operator informs Station Personnel of Breach	X	X
PF-002	Operators Confirm River Rise	X	X
PF-003	Operators execute emergency shutdown procedure	X	X
PF-004	Command and control transferred to Site Director	X	X
PF-005	Staffing levels determined and work planned	X	X
XF-001	Test SFMS DG-FL-1/2	X	X
XF-002	Start SFMS DG-FL-1/2	X	X
XF-003	Test SFMS Well Pumps P-1/2	X	X
XF-004	Stage and align portable pump for RCS make up	X	X
XF-005	Operators Open ADVs and confirm availability	X	X
XF-006	Block open ADVs to prevent re-closure	X	X
XF-007	Open MSSVs and prevent re-closure	X	X
XF-008	Fully Staff SFMS Facility	X	X
XF-009	Remove power to equipment below max WSE	X	X
XF-010	Open manual valves to align SFMS pumps	X	X
XF-011	Start SFMS well pumps	X	X
XF-012	Start portable pump for RCS make up	X	X
XF-013	RCS heats up to restore SG heat removal	X	X
XF-014	Operators maintain SG level, pressure & temp	X	X
XF-015	Operators refuel SFMS DGs	X	X
XF-016	Restaff + change shifts	X	X
XF-017	Regional Response Center Available	X	X
FRP-001	Initiate post-flood recovery plan	X	X

7.3 Methodology

Manual actions are evaluated to confirm that they are feasible and reliable. The evaluation performed for this scenario follows the guidance in Appendix C of JLD-ISG-2012-05. The feasibility and reliability assessments are performed as follows:

1. Using Table C1 and guidance contained in JLD-ISG-2012-05, Sections C.3.1 through C.3.1.13 evaluate any performance shaping factors that may affect the performance of manual actions in the flooding scenario. For PSF designated as nominal, a detailed justification is provided.
2. Perform a timing analysis to confirm that the time available to complete the action is greater than the time required to complete the actions when one considers uncertainties in the timing estimates. Specifically, for an action to be feasible, the ISG notes that "the time available must be greater than the time required when using bounding values that account for estimation of uncertainty and human performance variability".
3. Once an action is judged feasible, a reliability assessment is performed to determine whether sufficient margin exists to account for limitations of the analysis potential errors that may emerge as a result of time pressure and stress. While not a requirement, the ISG notes that an action may be justified as having adequate margin when "recovery from an error in performing an action could be accomplished by restarting the task from the beginning".

Prior to completing this manual action assessment all appropriate plant staff have been trained in the external flood protection/mitigation procedures. Site exercises on relevant procedures have been performed for all shifts. Note that in performing the timing analysis and margin assessments in the subsequent sections, unless otherwise noted, bounding times are obtained and/or inferred from site specific exercises or plant experience (when appropriate) have been used.

7.3.1 Event Timeline

A representative timeline for the scenario under consideration is presented in Table 5-1. Figure 6-1 illustrates the scenario success path consistent with that timeline. In that figure all human actions critical to a successful external flood mitigation are shown and grouped into three categories: initial pre-flood actions (actions PF-001 through PF-005), mitigation system deployment and implementation (actions XF-001 to XF-009), operation during flood (actions XF-010 to XF-015), long term response (actions subsumed under XF-016) and flood recovery (actions subsumed under XF-017). These actions will be evaluated in detail, using the guidance provided in Appendix C of JLD-ISG-2012-05, and justification for the any conclusions will be documented. A summary of actions considered in this assessment is provided in Table 7-1. Each of these actions have detailed MAEs presented in Section 7-4. The action IDs used here are consistent with the IDs used in previous sections. In performing the Section 7.4 assessment, each action has a short description, followed by the evaluation conclusions.

7.3.2 Related Environmental Factors

In executing outside actions, weather conditions are consistent with assumptions made in the Flood Hazard Re-evaluation Report. All actions taken inside buildings have been assessed to not be affected by external conditions. Weather conditions associated with this scenario are judged to not have a significant potential for causing an early loss of off-site power (See Reference 4).

7.3.3 External Interfaces

Successful preparation for and mitigation of dam failure events requires well defined interfaces with dam owners and various governmental agencies. In anticipation of such an event agreements have been previously executed between the USACE and the Utility such that the USACE will monitor dam hydrologic and physical conditions on a continuous basis and inform the utility of potential challenges to dam integrity and the advent of any event. Contact protocols are proceduralized and trained upon annually and are reviewed by the USACE staff during conditions where dam operators place the facility on high alert.

7.3.4 Governing Procedures

Response to the event is governed by inter-agency agreements, plant administrative procedures, and site emergency plans. Table 7-2 includes the procedures considered in this MAE. These procedures were reviewed and utilized in determining the most likely course of action the site will take during this scenario. Unless otherwise noted, utility procedures developed for responding to severe flooding challenges have been developed in advanced of the onset of the event and are developed following regulatory and standard industry and site practices in preparing emergency procedures. Procedures developed by the dam owner reflect standard practices of the USACE and any state and local guidelines that the facility may be required to adhere to. All procedures are readily accessible to site personnel and all site personnel both at the utility and dam facility are trained and tested on the procedures as part of the staff qualification procedures.

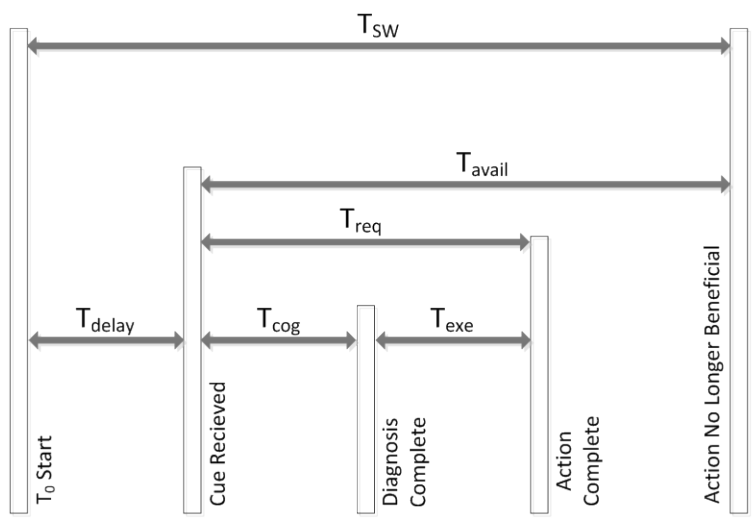
Table 7-2
Procedures Used or Referenced in the Dam BreaCH Scenario

PROCEDURE REFERENCE	REVISION	TITLE
AIA-001	1	USACE and Utility Interface Document
AOP-1234A	YY	Abnormal Operating Procedure – Upstream Dam Failure
AIA-002	1	RRC /NPP Agreement to Provide Resources Post-Disaster or Accident
FRP-001	YY	Flood Recovery Plan

7.3.5 Timing Analysis

In the following sections the human actions identified above will be evaluated. As discussed previously, the purpose of the evaluation is to demonstrate that individually, and in aggregate, the human actions associated with the scenario success path are feasible and reliable. Feasibility is established based on a review of performance shaping factors (i.e., procedures and training, staffing and availability of tools/components necessary to complete the task, etc.) and task timing analyses. One pragmatic way of demonstrating feasibility may include use of plant simulations. However, simulations must be judged with respect to the differences in environments between that of the simulation and that of the predicted event. Reliability is demonstrated via use of action time lines such as that in Figure 7-1, and confirmation that the available time window for performing an action is substantially below what it takes to become alert to the need to perform and execute the action.

Figure 7-1 Human Reliability Evaluation Timeline



The significant times important in MAE are:

- T_0 = start time or the point in time in a flooding scenario at which time the conditions exist that will require the human action
- T_{SW} = The time window within which the action must be performed to achieve its objective
- T_{delay} = Time Delay: or the duration of time it takes for the cue to become available that the action will be necessary
- T_{avail} = the time available for action = ($T_{SW} - T_{delay}$)
- T_{cog} = cognition time, consisting of detection, diagnosis and decision making
- T_{exe} = execution time including travel, collection of tools, donning PPE and manipulation of relevant equipment
- T_{req}= $T_{cog} + T_{exe}$

Time Margin is defined as:

$T_{margin} = [T_{avail}-T_{req}]/T_{req} \times 100\%$

7.4 Evaluation of Human Actions

This section provides a detailed assessment of human actions involved in implementing the flood mitigation strategy for the scenario. The MAE is intended to demonstrate that the actions involved in the flood mitigation strategy are feasible and reliable. Feasibility is assessed by integrating timing assessments of the human actions, available time windows, task complexity adequacy of procedures and training, and considerations regarding obstacles to performing the task imposed by environmental and psychological conditions through assignment of performance shaping factors (PSFs). In this assessment PSFs are qualitatively binned into one of three categories: Nominal, Moderate, or Degraded. For the scenario based approach adopted in this evaluation, feasible actions are those which the assessment identifies PSFs, with few exceptions, as Nominal.

Reliable actions are those which are feasible and have time margin to accomplish the task. For the purposes of the IA, reliable actions should have a time window for successful action completion at least twice that necessary to complete the action as measured from the initial cue.

In evaluating each human action the assessment includes the following:

- Description of the Action
- Performance Shaping Factor Assessment
- Human Event Timeline Associated with the ActionResource Assessment
- Conclusion

Note in the following evaluations, some related actions are grouped or convenience and clarity.

7.4.1 PF-001: Dam Owner Informs Station Personnel of Dam Breach

7.4.1.1 Description of Action

This action marks the onset of the scenario information to be provided to the site and represents the action by the dam owner to effectively monitor the dam condition. The USACE will be aware of potential threats to the integrity of the dam, diagnose incipient dam failure, and assign appropriate personnel monitor dam condition and initiation of breach. The dam owner maintains a continuously staffed facility at the dam.

While sunny day dam failures may have no clear incipient cause, these failures are often preceded by failure signs that may be monitored over time. In this facility, dam condition and status are monitored via reservoir level measurements in the control room and visual inspection of dam condition by onsite staff. Control room level monitors are continuously accessible and are calibrated periodically. Visual dam monitoring is available via remote video recorders, use of binoculars with a line of site view to the dam face and periodic walk-downs. Binoculars have night vision capability. Cues for actual dam failure are clear and unambiguous. Reservoir water level will decrease and sounds of water flowing and structural failure of retaining structures may be heard. Water levels in the river downstream of the dam and upstream of the site will increase. The dam operating staff is located in a protected area with a good view of the dam and out of harm's way during the breach process.

An agreement has been executed between the USACE and the Utility such that the USACE agrees to monitor the dam and provide daily status updates on dam condition and potential dam challenges. In the event of a an incipient dam breach the USACE will directly call the plant control room and provided access to river flood data and periodic updates of the progression of a flood event. The dam owner maintains an updated list of stakeholders to be called in the event of significant event at the dam. Such events include both planned and unplanned releases. The list is maintained in the dam control room both in a notebook and on site computers. Emergency response simulations are conducted by the USACE annually. A review of five exercises conducted over the past five years indicate that the nuclear site will be notified within 20 minutes of the onset of a dam breach.

USACE procedures are clear and unambiguous. Operating and emergency procedures are written to appropriate military standards. Operating staff is trained and tested on the procedures. Responsibility for key actions are well defined, as are the USACE and Utility contacts. Procedures exist to maintain contact information current.

Following a significant dam event, the dam operating staff protocol requires the dam staff to contact many stakeholders to ensure persons in the vicinity of the dam may take necessary actions. These calls involve contact with both state, and local authorities, and key employers. Calls are prioritized based on location of the stakeholder to the dam facility and risk impact. However, the timing used in this analysis assumes the conservative bounding case that the site is last to receive the call.

The action is simple and requires the USACE onsite staff to diagnose the event and call the nuclear site MCR upon detection of dam failure. Both cell and satellite phones are available for use. A table top emergency simulation is conducted annually with key stakeholders. The utility contact information is reviewed periodically to ensure it is current and prominently posted in the dam operating facility. No environmental actions (Table 7.4.1-1) are anticipated that would impact timely completion of USACE actions.

7.4.1.2 Assessment of Performance Shaping Factor (PF-001)

An evaluation of the performance shaping factors for action PSF-001 is presented in Table 7.4.1-1a. All PSF components are assessed to be Nominal as the action is straightforward and direction is unambiguous.

Table 7.4.1-1
Evaluation of PSFs for Flood Significant Actions
Action ID: Dam Operator Informs Station Personnel of Dam Breach (PF-001)

Action: Dam Operator informs Nuclear Station of dam breach

Discussion: Action is highly reliable. Appropriate procedures are in place for proper communication.

PSF	PSF Categories	Applicable Category	Justification
Cues and Indications	Nominal	X	Dam operator maintains routine surveillance on the dam. Examination includes visual surveillance and monitoring of reservoir levels. Cues for onset of failure may be noted by one or more of the following (1)unanticipated lowering of reservoir level,(2) visual observation of water outflow from dam structural components (3) sounds of water discharge or dam structural failure (4)unexpected increase in water level downstream of the dam. Reservoir level is monitored in the dam operator control room. This PSF is judged nominal as adequate cues and indications of dam failure are readily available for the dam operating staff to make an accurate assessment of failure.
	Degraded		
Complexity	Nominal	X	Diagnosis of event is simple, and dam breach should be unambiguous. A potential for inconsistency may exist if breach occurs during a dam discharge operation. This issue would be quickly resolved during significant dam failure issues of concern. Once a dam breach is identified, clear instructions are available as to when dam conditions warrant that the State and other stakeholders be informed. Required actions are straightforward. Staff is trained on dam release protocols including actions following inadvertent dam releases or dam breach. Execution tasks consist of a simple notification task. Identified USACE coordinator has current plant contact information and numbers are available from multiple sources including wall postings, notebooks and computer files. All files are routinely maintained and
	Degraded		

Table 7.4.1-1 **Evaluation of PSFs for Flood Significant Actions** **Action ID:** Dam Operator Informs Station Personnel of Dam Breach (PF-001)			
Action: Dam Operator informs Nuclear Station of dam breach			
Discussion: Action is highly reliable. Appropriate procedures are in place for proper communication.			
PSF	**PSF Categories**	**Applicable Category**	**Justification**
			actions are trained by USACE on an annual basis. Notification action will be taken within dam operator control room with minimal interference from other environmental factors. Agreements include specific actions to contact the utility upon notification of a pending or actual dam breach or conditions warranted high discharges from the dam. Based on above cognition and execution aspects of the action are considered nominal.
Special-Equipment	Nominal	X	Dam operator may rely on reservoir level monitors, video surveillance devices, and binoculars to ascertain and confirm onset of breach conditions. Upon execution of the notification phase the staff will rely on computers, cell phones and satellite phones to contact downstream stakeholders. Staff has been trained on use of the equipment required to execute the actions. All components are maintained in workable status via routine maintenance plans. Reservoir levels monitoring devices are maintained according to standard practices for the USACE. Note for night-time operation the staff has available night vision googles. All staff is trained in their use. This PSF is judged nominal as the number and type of special equipment are minimal and the staff is familiar and practiced in use of the equipment.
	Degraded		
Human-system Interfaces (HSI)	Nominal	X	The key instruments/gauges used in the process are located in the control room which is well lit. Gauges are sufficiently graduated to assess undesirable level reductions. Video and visual monitoring provide backup indications of breach. These added
	Degraded		

Table 7.4.1-1 Evaluation of PSFs for Flood Significant Actions **Action ID:** Dam Operator Informs Station Personnel of Dam Breach (PF-001)			
Action: Dam Operator informs Nuclear Station of dam breach			
Discussion: Action is highly reliable. Appropriate procedures are in place for proper communication.			
PSF	**PSF Categories**	**Applicable Category**	**Justification**
			observations may be less effective at night but are aided by the availability of flood lights which may be used to highlight a large portion of the dam face at night. If floodlights are unavailable night vision googles are available as a backup for visual observations. This PSF is judged as nominal as the HSIs are functional, accessible and may be used to monitor dam breach conditions
Procedures	Nominal	X	All dam operation and emergency procedures are developed in accordance with standard military practice and follow USACE procedure writing guidelines. Dam operating procedure AIA-001 spells out surveillance checks, and conditions requiring dam operator to immediately notify the site and other stakeholders. Procedures that identify means to diagnose dam breach, and are sufficiently comprehensive to address dam failure under a diverse set of circumstances. Procedures are accessible to the dam operating staff, and easy to understand. Procedures are maintained up to date according to USACE policies. All procedures are validated prior to implementation at the dam facility. This PSF has been judged nominal. All dam response procedures located in the dam operator control room, are clearly written, and clear protocols exist with the State that identifies situations when the USACE must notify utility. A specific section on emergency notification of stakeholders to uncontrolled dam releases is highlighted. Procedures are maintained up to date and include current contact information.
	Degraded		
Training and Experience	Nominal	X	Dam operators are trained in emergency operating upon being stationed at the facility and annually thereafter. Training includes full procedure walk through. USACE stakeholder exercises occur triennially.
	Degraded		

<table>
<tr><td colspan="4">Table 7.4.1-1
Evaluation of PSFs for Flood Significant Actions
Action ID: Dam Operator Informs Station Personnel of Dam Breach (PF-001)</td></tr>
<tr><td colspan="4">Action: Dam Operator informs Nuclear Station of dam breach</td></tr>
<tr><td colspan="4">Discussion: Action is highly reliable. Appropriate procedures are in place for proper communication.</td></tr>
<tr><th>PSF</th><th>PSF Categories</th><th>Applicable Category</th><th>Justification</th></tr>
<tr><td></td><td></td><td></td><td>This PSF is judged nominal as training is conducted in accordance with USACE guidance and operators participate in full procedure walk-throughs annually and specific simulated exercises with stakeholders are held periodically.</td></tr>
<tr><td rowspan="3">Workload, pressure , Stress</td><td>Nominal</td><td>X</td><td rowspan="3">USACE staffed by trained dedicated staff with adequate resources. Staff is located in a facility overlooking the dam and will not be directly impacted by event.

This PSF is judged as nominal as dam operating staff are well trained professionals, workload demand is manageable and the scope of actions under consideration is limited (i.e., downstream stakeholder notification)</td></tr>
<tr><td>Moderate</td><td></td></tr>
<tr><td>Degraded</td><td></td></tr>
<tr><td rowspan="2">Environmental Factors</td><td>Nominal</td><td>X</td><td rowspan="2">Dam operator staff can view dam conditions (e.g. water surface level, or face condition via visual inspection) remotely from an enclosure safe from potential harm. No significant impact of environmental conditions expected. Communications equipment (e.g., cell phones) are anticipated to be functioning during weather conditions associated with the re-evaluated hazard assessment.

[Adverse weather - Nominal/Degraded] Nominal.
The action is performed in a room in typical conditions. Operations are therefore not impacted by environmental conditions.
[Temperatures - Nominal/Degraded] Nominal.
The action is performed in dam control room. Operations are therefore not impacted by environmental conditions.
[Potentially Hazardous Conditions - Nominal/Degraded] Nominal.
The action is performed in dam control room. Dam operating staff is not subjected to unusual hazards.</td></tr>
<tr><td>Degraded</td><td></td></tr>
</table>

Table 7.4.1-1 Evaluation of PSFs for Flood Significant Actions **Action ID:** Dam Operator Informs Station Personnel of Dam Breach (PF-001)			
Action: Dam Operator informs Nuclear Station of dam breach			
Discussion: Action is highly reliable. Appropriate procedures are in place for proper communication.			
PSF	**PSF Categories**	**Applicable Category**	**Justification**
			[Lack of Lighting - Nominal/Degraded] Nominal. The action is performed in dam control room. Room is well lit. Emergency power is available to maintain adequate power levels in control room for 24 hours following a local loss of offsite power. [Radiation - Nominal/Degraded] NA Actions not performed near a source of radiation. [Noise - Nominal/Degraded] Nominal. Dam breach and large water flow may result in noisy environment. However, relationship between the dam control room and the dam is sufficiently far so that noise generated from the breach will not prevent staff from performing their contact activities. Note e-mail back-up notification capability also exists. [Vibration - Nominal/Degraded] Nominal. No significant vibration impacts in the control room apart from that that may be felt during a dam breach.
Special Fitness Issues	Nominal	X	No unique fitness requirements are needed for performing this activity. Sufficient staff available to perform actions as dam facility is continuously manned. This activity is judged nominal.
	Degraded		
Staffing	Nominal	X	Sufficient availability of qualified staff will be continuously available to perform observations and external contacts. Adequate staff and resources (food, cots, etc.) exist in the facility to accommodate extended staff deployment if necessary and perform intended actions. This activity is judged nominal
	Degraded		
Communications	Nominal	X	Communication program in place between all parties – Utility, State and USACE (see, Reference 7). External communications activity simulated at contract onset and triennially thereafter. Contacts list maintained up to date. Multiple means of external communication exist including cell phone and e-mail (pre-addressed to stakeholders). Local communication among dam operating staff via satellite phone is also available.
	Degraded		

Table 7.4.1-1 Evaluation of PSFs for Flood Significant Actions **Action ID:** Dam Operator Informs Station Personnel of Dam Breach (PF-001)			
Action: Dam Operator informs Nuclear Station of dam breach			
Discussion: Action is highly reliable. Appropriate procedures are in place for proper communication.			
PSF	**PSF Categories**	**Applicable Category**	**Justification**
			This PSF is judged nominal.
Accessibility	Nominal	X	Accessibility to facility for tracking dam is remote from the dam, allows for dam access and visual inspection, as necessary and is positioned away from any consequences of a dam failure. Adequate provisions are available to maintain existing staff on site should relief staff be delayed due to external hazards. This PSF is judged nominal.
	Degraded		

7.4.1.3 Human Action Timeline

Success of this action is that the USACE notifies the site MCR within 1.0 hour of the onset of a significant breach of the dam. Should this notification be delayed downstream river level monitors will identify an unusually high river level immediately following the event, limiting the potential uncertainty in breach notification. These downstream river gauges are monitored in the NPP control room.

Data for establishing diagnosis and execution times have been obtained from table top exercises performed on dates 03/11/2013, 06/30/2014 and 09/30/2014. Exercises involved all crews and included both day and night shifts. A summary of the exercises are provided in Reference 25. Based on a review of results of these exercises bounding time estimates for the various activities were provided.

Using the formalism identified in Section 7.2, the components of the human response assessment are summarized in Table 7.4.1-1b.

Table 7.4.1-2 Response times for Action PF-001 (All times referenced to dam breach at T=0)		
Time Response Component	**Time (hr)**	**Basis**
T_{delay}	0.15 (9 min)	Cue is an unanticipated decrease in reservoir level. Other cues, including visual and auditory alerts may be coincident. Timing of cue may be different based on severity of event. For severe events where prompt action is expected (dam failure) cues will be rapid and clear. Based on a review of simulation exercises, a 10 minute time to understand the significance of the event unfolding is judged to be bounding. This was the time at which the reservoir level was unexpectedly noted to drop [1 foot]. Slower dam degradation events may take more time to unfold, but flow discharges over that time would not be critical to downstream sites.
T_{cog}	0.0167 (1 min)	The cognitive time is considered to be the time from the actuation of the alarm to the point where the dam operator decides to confirm that the dam has breached. All operating crews began stakeholder contact procedure once the unanticipated decrease was recognized. A bounding time of 10 minutes was estimated to be needed to identify that an emergency condition exists and to open the appropriate dam operation procedure. A significant dam breach should produce both visual and sound effects and the event should be dramatic.
T_{exe}	0.333 (20 mins)	Once a dam breach is confirmed, dam owner will take actions to notify utility management and will directly contact the control room staff. Exercises indicate that once the cue is received, the site has been contacted within 20 minutes (with a median response time of 15 minutes). See Reference 25.
T_{SW}	1.00	Anticipated allowable time for action. See discussion below.
T_{avail}	0.85	Time Available
T_{req}	0.500	Time Required after delay
T_{margin}	70%	Time Margin

Note that the time window for this anticipated action was set at 1.0 hour from breach initiation. This was selected as a reasonable window for the action since delay of the action beyond one hour would result in a back-up water level indication in the nuclear plant control room. This alarm is tested annually and periodically maintained by the utility. The nuclear plant control room high river level alarm has never provided false indications and has been known to be effective in confirming a high water level condition resulting from preventive large controlled dam discharges in the past. Once confirmed, high river level indications resulting from this alarm will initiate entry into AOP-1234 for external flood protection and mitigation (See Section 7.4.2).

Results of the PSF assessment in Section 7.4.1.2 indicated that all PSFs are nominal. The timing assessment included in this section indicates that when using bounding estimates of manual response times, the action may be completed within the available time interval. Furthermore, use of bounding values in the timing assessments inherently includes considerations of uncertainties. Therefore, consistent with the guidance of Appendix C of the ISG, the action is considered feasible.

7.4.1.4 Reliability Assessment

As previously stated in Section 7.4.1.1 above, the action was determined feasible. A review of the timing assessment also indicates that the overall action has a margin of 67%. As the action considered in this assessment is simple the margin is considered sufficiently large so as to consider this action as reliable. Delay in the time of identification of the onset of a catastrophic dam breach will reduce available time for plant staff to prepare for and mitigate the ensuing flood. However, the time delay impact is limited as river flood gauges downstream of the dam provide abnormal river level indications that are alarmed and may be trended in the nuclear plant control room.

7.4.1.5 Resource Assessment

USACE has adequate resources to fulfill their commitments. Facility continuously manned by at least two operators.

7.4.1.6 Conclusion

Dam Owner/Utility exercises indicate that action PF-001 is feasible and reliable. Action can be completed within the 1 hour anticipated window, following simple, clear and proceduralized actions with a time margin of 70 %.

7.4.2 PF-002: Operators Confirm River Rise

7.4.2.1 Description of Action

Following a failure of the upstream dam, the plant operators will be notified by the dam owner of an impending event. Receipt of this cue will require reactor operators to enter the AOP-1234A. Among the many post plant actions initiated by the notification, AOP-1234A requires the plant to monitor the progress of the flood so as to better understand the expected level at the site and timing of impact. Several monitoring locations are located upstream of the plant. An unanticipated abnormal rise in river immediately downstream of the dam will annunciate in the MCR of the NPP and provides a visual and audible alarm to the operator. (This alarm provides a backup cue should notification not be received earlier via verbal notification.) Note that abnormal rise alarm will alert the staff when the river level monitor is [50%] over anticipated nominal river elevations resulting from defined controlled discharges. Note that an alternate monitoring path for these devices is also available through the USACE website. Success of this action includes the operators confirming an abnormally high dam discharge. This may be done by direct contact with the USACE (i.e., being directly informed by dam operator) or by correctly identifying and confirming the high river level alarm. Acknowledgement of this condition via either method will allow the initiation of the correct subsequent actions.

The initial cue for this action is (1) either direct contact of the MCR by the dam operator or (2) River Upstream Rate of Change and High Level Alarm

The setpoints for the alarms are:

- River level rate of change exceeds +2.5 feet from the previous hour (Reference 13)
- River water surface elevation exceeds 890.00'

Instruments and setpoints for these gauges are calibrated annually by the USACE. Records of calibrations are available for review.

Notification by the USACE or triggering of an alarm will cause the operators to enter AOP-1234A. Following entry into this procedure, operators will proceed to execute Steps X.X. Specifically, once the River Level Rate of Change /High Level alarms annunciates, the shift supervisor will confirm the alarm and that USACE has notified the site of a dam breach. If the USACE has not contacted the site, then the site should make contact by calling the on duty USACE technician to visually confirm the dam breach.

Analysis has shown that this alarm will provide operators with adequate indication that the upstream dam has failed and emergency procedures should be entered (Reference 13). Confirmation with the USACE (dam owner) will have occurred and the conclusion of a dam failure should not be ambiguous. Thus the degree of Clarity of Cues and Indications is considered very good.

A review of the procedure confirms that the procedure clearly defines the identification of the River Rate of Change/High Level alarms and the subsequent action to confirm dam failure with the USACE. This procedure is trained on annually along with all other AOPs. Operators are periodically tested on external hazard AOPs of which external flood included. The particular step is part of a scenario that requires operators to identify that the alarm may indicate a dam failure and that confirmation is required.

Comments on past Industry Experience

The plant has not had an upstream dam failure event in the past. A review of industry events for additional insights related to this action was not performed given the site specific nature of this action. Key factors that could influence the action are related to the ability of (1) the reactor operator to contact the dam operating staff to validate the dam break condition, and (2)the USACE personnel to interpret the nature of the dam failure, and then to take the responsibility to declare a dam failure. Other industry events would likely provide only very general insights that would not considerably enhance the understanding of this action.

Comments on plant and plant/dam owner exercises

The utility trains on flood scenarios including those related to dam breach every outage. Utility specific training involves response to control room alarms indicating high water level immediately downstream of the dam. The alarm is associated with a calibrated level. Normally, the dam owner will inform the utility of planned discharges that will cause the alarm in the MCR to actuate. Drills involve situations where pre-warning has not occurred. Given the anomalous alarm the response of operators to follow the high water level alarm procedure are observed and time responses recorded. All shifts and multiple crews are exposed to this exercise at a frequency in accordance with the plants drill program.

Joint dam owner utility exercises are conducted on a triennial basis. Both exercises will result in the utility staff consulting AOP-1234A and following well defined procedures. The timings identified in Section 7.4.2.3 reflect the bounding time experienced for the various crews. Exercises are conducted on all shifts. This assessment therefore considers crew variability in the feasibility assessment. Most recent exercise was conducted on 06/30/2014. Results of simulation indicated site would declare an Unusual Event (UE) and enter AOP-1234A no later than 15 minutes of confirmation of the dam breach.

7.4.2.2 Assessment of Performance Shaping Factors for Action PF-002

An evaluation of the performance shaping factors for action PF-002 is presented in Table 7.4.2-1a. All PSF components are assessed to be Nominal.

Table 7.4.2-1

Evaluation of PSFs for Flood Significant Actions

Action ID: PF-002

Action: NPP Operators confirm river rise and enter AOP-1234A

Discussion: Action is highly reliable. Appropriate procedures are in place for proper communication.

PSF	PSF Categories	Applicable Category	Justification
Cues and Indications	Nominal	X	The cue for this action is provided by either a call from the USACE or an alarm that would actuate on a high water level condition downstream of the dam and upstream of the site. The alarm would actuate in the MCR where an operator would acknowledge the alarm and contact USACE to confirm the high tailrace water level condition and to evaluate the cause. (The high water level alarm is presented both as an audible alarm in the MCR and a visual display on the control room wall.) It is most likely that the USACE would notify the site immediately of a dam failure, however procedure AOP-1234A Steps X.X directs operators to contact the USACE to confirm the cause of the high level alarm is in fact an uncontrolled/unanticipated release. A conservative assumption was used in the timing analysis for the purposes of this evaluation and assumes that the site does not get
	Degraded		

Table 7.4.2-1
Evaluation of PSFs for Flood Significant Actions

Action ID: PF-002

Action: NPP Operators confirm river rise and enter AOP-1234A

Discussion: Action is highly reliable. Appropriate procedures are in place for proper communication.

PSF	PSF Categories	Applicable Category	Justification
			contacted by the USACE prior to the alarm. As the cues are clear (either a phone call or a high remote river level alarm) the PSF was judged to be nominal. Further, the remote alarm is periodically calibrated and is readily observable by all operating staff. See action discussion for signal reliability.
Complexity	Nominal	X	Action is judged to be nominal as this action is straightforward and limited in scope. On River Level Rate of Change/High Level alarm, the MCR operator is directed to contact to confirm the validity of the alarm with USACE. Concurrent alarms should include tailrace level rate of change alarms, but these would provide confirmation that the high level signal is valid and AOP-1234A directs the same action for the rate of change alarms. Making a telephone call or a radio call after identifying the high level condition is of negligible complexity. Alternate means of confirming increase would be from monitoring the level device on the USACE internet site. SRO has responsibility for confirming condition and entering appropriate AOP.
	Degraded		
Special-Equipment	Nominal	X	The only equipment required for this action is the control board and a phone. The alarm is fed by multiple river monitoring devices that are periodically tested. Significant breach events are also expected to be reported by the dam owner /operator and monitored by the USACE. Operator is familiar with equipment / indications as they are called out in the procedure and are included in training exercises. Direct contact from USACE of a significant unplanned discharge immediately triggers entry into abnormal external flood procedure (AOP-1234A) . Contacts and methods to confirm high level signal independently are well defined and proceduralized. Procedures are maintained up to date and
	Degraded		

Table 7.4.2-1
Evaluation of PSFs for Flood Significant Actions

Action ID: PF-002

Action: NPP Operators confirm river rise and enter AOP-1234A

Discussion: Action is highly reliable. Appropriate procedures are in place for proper communication.

PSF	PSF Categories	Applicable Category	Justification
			contact numbers and relevant websites Direct contact entry into procedures requires no special equipment. Use of river gauge/alarms is a trained action and simple procedures to confirm signals exists (e.g direct contact with USACE). Therefore, PSF is judged to be nominal.
Human-system Interfaces	Nominal	X	The instrumentation relevant to this action is simple level alarm indicators, which have their set points listed in AOP-1234A and are easily interpreted and seen from most vantage points in the MCR. The indicators would be used for the purposes intended and would be checked under nominal control room conditions. The only other interface required for the execution portion of this action would be the telephone. The use of these communication tools is considered to be highly familiar and of negligible difficulty. Thus this PSF is judged to be nominal.
	Degraded		
Procedures	Nominal	X	All procedures are prepared in accordance with standard site procedures for preparing emergency procedures. All alarms are clearly identified, two column formats are retained and actions for response and no response obtained are provided. This action is based on an alarm response procedure. The alarm description is clear, the procedure lists the conditions that would actuate the alarm, and provides a description of what could cause the alarm (dam failure). The procedure also clearly lists the actions that are required to be taken by the MCR. In addition, a review of the procedure conducted for assessing this action concluded that − The procedure addresses the conditions that would exist in a dam break scenario. − The procedure is maintained current by the utility. − The procedure has been communicated with the
	Degraded		

Table 7.4.2-1
Evaluation of PSFs for Flood Significant Actions
Action ID: PF-002

Action: NPP Operators confirm river rise and enter AOP-1234A

Discussion: Action is highly reliable. Appropriate procedures are in place for proper communication.

PSF	PSF Categories	Applicable Category	Justification
			USACE. – The procedure is clear and unambiguous. This PSF is therefore judged to be nominal.
Training and Experience	Nominal	X	Training is performed on an annual basis, as are all AOPs. During this training, operators are given that the high level or rate of change alarm has sounded then made to continue working through the procedure. This exercise gives the operators familiarity with the alarm's meaning and subsequent actions required to confirm its validity. Operator training on this procedure last occurred on XX/XX/xxxx. Training occurred on all plant shifts. All actions were properly executed and response times for the actions were recorded. All actions were completed within the targeted action response time.
	Degraded		
Workload, pressure , Stress	Nominal	X	For the "sunny day" dam break, the alarm would register, on average, at a time when the operators' workload is not at a level that challenges their capacity. For the USACE, there is no physical threat, so there is no stress for the operators related to their personal well-being. The current analysis predicts a relatively long time would be available to allow the plant to prepare for the flood water, but even in the catastrophic break scenario, there was adequate time for the plant to prepare. In addition, the requirements of the procedure/scenario on the MCR operators are simple and limited in scope, which would greatly limit the potential for stress. While it is recognized the plant staff is not personally under a physical threat and adequate staff is available to perform the necessary plant preparatory operations, a large flood resulting from a dam break may impose psychological stress on the staff. The plant staff is comprised of professionals and expected to perform their functions. Plant has made provisions to accommodate particular staffers whom may
	Moderate		
	Degraded		

Table 7.4.2-1 Evaluation of PSFs for Flood Significant Actions **Action ID:** PF-002			
Action: NPP Operators confirm river rise and enter AOP-1234A			
Discussion: Action is highly reliable. Appropriate procedures are in place for proper communication.			
PSF	**PSF Categories**	**Applicable Category**	**Justification**
			need special relief for such events based on where they or certain family members may be domiciled. Adequate staff is available and on call to fill in for such conditions. Initial alarm response actions are routine, frequently trained upon and simple to execute. This PSF was judged to be nominal, but under certain circumstances the PSF may rating may be moderate.
Environmental Factors	Nominal	X	All actions are taken within the control room. The facility is well lit and has alternate power in the event of a loss of offsite power. As all actions in PF-002 are taken in sheltered, safe areas there is no direct impact of external hazards on the staff. [Adverse weather - Nominal/Degraded] Nominal. The action is performed in a control room. [Temperatures - Nominal/Degraded] Nominal. The action is performed in a control room [Potentially Hazardous Conditions - Nominal/Degraded] Nominal. The action is performed in a control room. [Lack of Lighting - Nominal/Degraded] Nominal. The action is performed in a control room. Control room is well lighted. [Radiation - Nominal/Degraded] Nominal. Not performed near a source of radiation. [Noise - Nominal/Degraded] Nominal. Not performed near a source of loud noise. [Vibration - Nominal/Degraded] Nominal. No significant vibration impacts in the control room
	Degraded		
Special Fitness Issues	Nominal	X	There are no significant physical requirements related to observing a control board alarm and making a telephone
	Degraded		

Table 7.4.2-1
Evaluation of PSFs for Flood Significant Actions

Action ID: PF-002

Action: NPP Operators confirm river rise and enter AOP-1234A

Discussion: Action is highly reliable. Appropriate procedures are in place for proper communication.

PSF	PSF Categories	Applicable Category	Justification
			call. PSF is judged nominal.
Staffing	Nominal	X	Initial phase of plant response may be accommodated with plant at normal plant staffing levels. No severe environmental conditions are expected to exist for a "sunny day" break that would predict adequate site staffing. This PSF is considered nominal.
	Degraded		
Communications	Nominal	X	All communication capabilities are expected to be available. For a "sunny day" break, communications are not expected to be impacted. This PSF is considered nominal.
	Degraded		
Accessibility	Nominal	X	Control room action. No access issue identified for this phase of the event. This PSF is considered nominal.
	Degraded		

7.4.2.3 Time Window

The anticipated time for the flood to reach site grade is 24 hours (including consideration of wave run up). The 900 ft. level (including margin for wave run up) may be reached as early as 30 hours after the initial dam breach. A peak flood height of 905 ft can potentially be reached 6 hours later. Given the expected sequence of events, operators stress for the initial actions will not be degraded.

Furthermore, the initial response to the alarm (or the dam owner call) occurs in a control room that would not be physically impacted by the dam break event. Given that the initiating event is a "sunny day" dam break and considerable time is required for water to reach the site, no adverse conditions are expected to exist in the control room.

All site abnormal procedures are prepared in accordance with standard approved site preparation procedures. Training of associated personnel is conducted annually and are in accordance with INPO systematic approach to training.

An assessment of the expected operator action times associated with action PF-002 is presented in Table 7.4.2-2.

Table 7.4.2-2 Response times for Action PF-002.		
Time Response Component	**Time (hr)**	**Basis**
T_{delay}	0.033 (direct call)	Initial cue for operator action is either (1) a direct call to the control room from the dam operator or (2) an audible and visual alarm noting that the river water level downstream of the dam indicates a potentially significant unplanned discharge. When a call is placed directly to Main Control Room (MCR) the cue is immediate and unambiguous. A two minute delay is assumed. This delay time is based on a bounding expected response of the operator to a direct cue. Response is trained, and requires operator to enter an appropriate procedure. Action is judged to be nominal.
	0.50 (initial dam breach)	This is a response to a backup signal and includes measurement delay, and delays associated with the operator in taking confirmatory actions. The dam break would result in River Level Rate of Change/High Water level alarms in the tailrace after approximately 20 minutes. This is shown as a reliable back-up to the direct call from the dam owner. An additional 10 minutes is added to the delay to reflect uncertainty in operator action which method to confirm the signal.
T_{cog}	0.05	The nominal cognitive time is considered to be the time from the actuation of the alarm to the point where the MCR decides to confirm that the dam has breached. This is estimated to be 3 minutes (one minute to refer to the alarm response plan and another two minute to determine the course of action). (0.05 hours). If confirmation from the USACE is required the response may be delayed an additional 5 minutes.
T_{exe}	0.5	The execution time for this task is the time required for the MCR to recognize the alarm, refer to the applicable procedure, and confirm that the USACE has declared a failure, open AOP-1234A and begin initial actions. If USACE has not already contacted the site, then a call is required to the USACE to confirm dam failure. The time required if the USACE has already called is estimated to be 5 minutes. As a conservative estimate, this analysis will use 30 minutes to allow time to contact USACE and confirm

		dam failure and declare an Unusual Event where entry to AOP-1234A begins. This value is bounded by results of previous exercises conducted on dates 03/11/2014 and 06/30/2014. Completion of this activity results in a site declaration of an UE.
T_{SW}	1.5	Anticipated allowable time for action. Assumes combined window for actions PF-001 and PF-002 is 2.5 hours. Longer time windows will be acceptable, however delays would reduce margin for completing other preparatory tasks, and delays in excess of 8 hours would jeopardize completion of preparatory activities in the presence of a dry site.
T_{avail}	1.467	Time Available after delay
T_{req}	0.333	Time Required to perform the action
T_{margin}	166.73%	Time Margin (>>100%)

Results of the PSF assessment in Section 7.4.2.2 indicated that all PSFs are nominal. The timing assessment included in this section assumed bounding response times. This assessment further indicated that when using conservative timing values and considering uncertainty the action may be completed within the available time interval. Therefore, consistent with the guidance of Appendix C of the ISG, the action is considered feasible.

7.4.2.4 Reliability Assessment

Action can be performed with ample margin. Action is a routine action. Periodically trained upon and entirely completed the control room. Task is simple to perform and adequate staff is available to perform necessary actions. The anticipated margin to perform action exceeds 100%.

7.4.2.5 Resource Assessment

The only personnel required for this action include an SRO to confirm that a dam breach has occurred and that the rate of change/high level alarm is correct. Normal plant staffing is adequate to implement this action.

7.4.2.6 Conclusion

This action requires the operator to respond to a clear and simple annunciated cue in a typical control room environment with PSFs that are all nominal. The "execution" portion of the action is of negligible difficulty, which is also conducted in typical control room environment. The time available to perform the action is 1.5 hours, which was shown to have adequate margin under conservative assumptions. No factors have been identified that would complicate the response. All PSF categories were assessed to be Nominal.

An assessment of the action timeline indicates that the action time window is 1.5 hours and the time required to complete the desired action is 0.717 hours indicating a time margin of 166.7%. As noted in Table 7.4.2-2, operator action time windows may be considerably longer. Delays in this action would reduce margin for completing downstream site readiness preparation tasks. As the time margin exceeds 100%, the action is judged reliable.

7.4.3 PF-003: Operator Shutdown Reactor

7.4.3.1 Description of Action

Action is governed by EOP-1234A, Steps X through Y. This is a highly reliable action with clear cues (management shutdown requested per AOP-1234A which triggers entry into shutdown EOP), procedures are well defined and clearly written in accordance with site standard practice, action is taken in the MCR, operators are trained and tested on the action periodically and time windows assigned to complete this action are ample. At this stage in the event, the stress of an impending flood would result in nominal performance shaping factors. Time window for action is based on operator interviews, and a review of plant experience in implementing the shutdown procedures EOP assessment (See Table 7.4.3-1).

7.4.3.2 Assessment of Performance Shaping Factors for Action PF-003

The first steps upon entry into AOP 1234A is to commence an orderly plant shutdown. This action is included in the plant EOPs and is frequently trained upon and is included in operator testing. The plant shutdown actions completely occur within the control room and the initial phase of the external flood shutdown does not deviate in any significant manner from a routine technical specification driven plant shutdown operation. These operations are routine and reliable and there is ample site specific evidence that such a shutdown can be accomplished in the anticipated assigned time window. As discussed in Section 7.4.3.3, a significant amount of time margin exists in the scenario timeline and therefore, the action can be considered highly reliable.

7.4.3.3 Time Window

Actions to shutdown reactor are included in existing plant procedures. These actions are well trained, and timings are consistent with operator expectations and past experience. They will be performed well in advance of flood waters and adverse conditions. Expected time responses are provided below.

Table 7.4.3-3a
Response times for Action PF-003

Time Response Component	Time (hr)	Basis
T_{delay}	0.05	Cue comes from SRO to enter AOP. Cue is clear and unambiguous. Time delay is time necessary to open AOP-1234A, step XX of which sends operator into EOP-1234A. 0.05 hr. is taken as a bounding value to receive order from SRO and locate and open AOP-1234A. Timing assessment is based on operator interviews.
T_{cog}	0.05	Well trained action. Time for operator to get to procedure step to follow EOP-1234 to shut down reactor.
T_{exe}	6	Operator follows EOP-1234A for aggressive cooldown. Timing assumes cooldown rate of between 50 and 75 F/Hr SDC entry conditions involve reaching entry conditions of 350 F and 300 psia. Operators are routinely trained in this evolution. Plant experience with aggressive cooldowns indicates the process to cooldown the plant to shutdown cooling entry conditions and align the plant for SDC operation can be reliably completed within 6 hours.
T_{SW}	12	Anticipated allowable time for action. Completion of action within this time frame will not impact parallel site preparation activities.
T_{avail}	6	Time available after delay
T_{req}	12	Time required to perform action
T_{margin}	100%	Time Margin

7.4.3.4 Summary Feasibility/Reliability Assessment for Action PF-003

This action is included in the plant EOPs and is frequently trained upon. The action completely occurs within the control room and does not deviate in any significant manner from a normal plant shutdown operation. These operations are routine and reliable and there is ample site specific evidence that such a shutdown can be accomplished in the anticipated assigned time window. Given the routine nature of this action and the protected environment in which the actions are performed, all PSFs associated with PF-003 have been judged to be nominal. As actions can be completed within well within the available time window including considerations of uncertainties associated with performing this action (which are considered small), the overall action is judged feasible. As a significant time margin exists in the scenario timeline, the action can be considered highly reliable.

7.4.3.5 Resource Assessment

Normal plant staffing is adequate to implement this action.

7.4.3.6 Conclusion

This action requires the operator to respond to a clear and simple annunciated cue in a typical control room environment with PSFs that are all nominal. An assessment of the action timeline indicates that the action time window is 12 hours and the time required to complete the desired action is 6.1 hours indicating a time margin of 100%. As this action is well trained and is performed in a nominal environment the time margin is considered sufficient to consider this action reliable.

7.4.4 Align and Test SFMS DGs (Action XF-001)

7.4.4.1 Description of Action

Action initiated by MCR as part of AOP-1234A. Action includes dispatching staff of two operators to the SFMS facility. The purpose of this set of actions is to ready the SFMS DGs, support components for extended operations and confirm availability of adequate fuel resources. The two individuals are tasked with:

(1) Unlocking and prepare SFMS facility for use

(2) Confirm operability of fuel oil transfer pump and availability of long term makeup to the day tank

(3) Start and run DG for 15 minutes

Actions are taken while the site is dry. The SFMS facility is constructed to be above the peak flood hazard elevation.

To establish the reliability of these actions the operators are periodically trained in the procedure and are exposed to periodic drills/exercises during every outage. Results of these drills have been recorded and expected median and bounding times have been established for a variety of crews and initiation scenarios. Bounding values obtained from multiple exercises indicates that operators can effectively complete this activity in 75 minutes. This includes diagnosis of the need to take action, transport time to the SFM Facility and associated actions and validation efforts. This bounding time is based on a night shift time response. Transport time from the MCR to the SFMS is estimated to take less than 15 minutes and includes consideration of potential adverse weather conditions (consistent with conditions reported in the hazard re-evaluation report. Once the facility is entered, all subsequent actions are taken in a weather protected environment with adequate ergonometric conditions.

Keys to unlock the facility are available in the MCR. Any necessary tools to perform required functions in the SFMS facility are stored in a clearly identified location in that facility.

No diagnosis is required for baseline actions. The action is initiated under direction of the MCR and specific actions to be performed in the SFMS facility are included in AOP-1234A. Operators are trained in this activity however; specific activities included in the procedures are simple and require no specific skill-set. Tools to facilitate turning of valves are stored in clearly identified locations within the SFMS. The day tank is maintained full.

Timeline for actions included in these procedures MCR is presented in Table 7.4.4-2. Affected staff is periodically trained on the readying process for the SFMS. Initial training on the SFMS implementation procedure was conducted on 04/26/2013. Severe flood simulation drills are performed annually. The timings provided are based on maximum timings from results of two site walkdowns of the associated procedures conducted on 04/30/2013 and 06/30/2014. Annual site drills confirm these values to be bounding.

7.4.4.2 Assessment of performance Shaping factors for Manual Action XF-001

An assessment of the PSFs associated with performing manual action XF-001 is presented in Table 7.4.4-1. These actions represent unique actions for responding to a severe external flood event. A review of the PSFs included in Appendix C of the ISG was considered sufficiently comprehensive for evaluating the associated performance environment. Note action XF-001 is completed prior to the flood waters reaching the site. No additional scenario specific PSFs were identified.

Table 7.4.4-1a
Evaluation of PSFs for Flood Significant Actions XF-001

Action ID: SFMS DGs tested and Aligned per Procedure AOP-1234A

Action: Crew dispatched from MCR to (1) unlock and prepare SFMS DGs for use (2) Confirm operability of fuel oil transfer pump and availability of long term makeup to the day tank (3) start and run SFMS DG for 15 minutes

Discussion: Action taken well in advance of floodwaters reaching site grade. All subordinate actions are proceduralized.

PSF	PSF Categories	Applicable Category	Justification
Cues and Indications	Nominal	X	Direction to prepare facility and align SFMS DG system included in AOP-1234A
	Degraded		
Complexity	Nominal	X	Action is simple, proceduralized and trained on at least once annually.
	Degraded		
Special-Equipment	Nominal	X	No special equipment required
	Degraded		
Human-system Interfaces	Nominal	X	The SFMS facility has similar interfaces to the MCR and the operators are trained on using the equipment every outage. It is not expected that any controls or alarms will be ambiguous.
	Degraded		
Procedures	Nominal	X	Procedure used for identified action(s) are written in accordance with industry guidelines and standard site practice.
	Degraded		
Training and Experience	Nominal	X	Flood mitigation AOP actions trained on annually
	Degraded		
Workload, pressure , Stress	Nominal	X	Adequate staffing is available to ensure low workload. Time to take action is adequate (see Table 7.4-4a) and shows significant time margin. Two individuals
	Moderate		
	Degraded		

Table 7.4.4-1a Evaluation of PSFs for Flood Significant Actions XF-001 **Action ID:** SFMS DGs tested and Aligned per Procedure AOP-1234A			
Action: Crew dispatched from MCR to (1) unlock and prepare SFMS DGs for use (2) Confirm operability of fuel oil transfer pump and availability of long term makeup to the day tank (3) start and run SFMS DG for 15 minutes			
Discussion: Action taken well in advance of floodwaters reaching site grade. All subordinate actions are proceduralized.			
PSF	**PSF Categories**	**Applicable Category**	**Justification**
			dispatched to SFMS facility and the task is done early in scenario progression well in advance of floodwaters reaching site grade. Psychological stress is minimized as much of surrounding region not directly impacted by flood. For plant individuals with family in need of help for potential evacuation or other actions, specific individuals can be released. Staffing process ensures a minimum required staff will be available throughout the entire event.
Environmental Factors	Nominal	X	See supplemental Table 7.4.4-1b
	Degraded		
Special Fitness Issues	Nominal	X	Actions do not have a requirement for strength or special fitness.
	Degraded		
Staffing	Nominal	X	Resource loading plans are established and implemented so adequate resources are expected.
	Degraded		
Communications	Nominal	X	Communication is via satellite phone
	Degraded		
Accessibility	Nominal	X	Keys for doors of the SFMS facility are located in the MCR and sufficient copies are available to ensure adequate access. The SFMS facility is located at an elevation above the highest credible flood level determined by the hazard re-evaluation and the SFMS will be staff prior to flood waters arriving.
	Degraded		

Table 7.4.4-1b Assessment of ISG Appendix C Environmental factors for PSF XF-001			
Action ID: SFMS DG's tested and Aligned per Procedure AOP-1234A			**Assessment**
Environmental Factor	**Impact Assessment**	**Comment**	**Nominal/Degraded**
adverse weather (e.g., lightning, hail, wind, precipitation)	Actions may have to be executed in an adverse wind environment. While wind speed typical of that used in the FHRR can create difficulties in moving from the MCR to the SFMS facility, availability of utility trucks would facilitate transport under those conditions. Impact of high speed winds has been factored into the HRA assessment through increasing maximum response times. Note utility vehicles are not impacted by wind environments up to [50 mph.]	All operational activities are executed within a weather protected structure and are therefore not influenced by external winds.	Degraded
temperatures (e.g., humidity, air and water temperatures, particularly if personnel must enter water)	Area not susceptible to extreme weather conditions. DG operates building HVAC, as well as, other comforts such as lighting, refrigerator and communication information.	Building environment controlled by plant power until SFMS DGs are operational. HVAC supported by the SFMS DGs. Doors, vents and fans are available in case of HVAC failure.	Nominal
conditions hazardous to the health and safety of personnel (e.g., electrical hazards, hazards beneath the water surface, drowning, structural debris)	No hazardous conditions exist during facility preparation.	Facility is above maximum potential flood height. Key indications and equipment are located in facility. Roads to and from facility to adjacent community available during maximum flood for facility re-supply from off-site sources.	Nominal
lack of lighting	Facility is well lit.	Replacement lights available. Back-up battery powered lanterns and flashlights /head lamps and	Nominal

Table 7.4.4-1b Assessment of ISG Appendix C Environmental factors for PSF XF-001			
Action ID: SFMS DG's tested and Aligned per Procedure AOP-1234A			**Assessment**
Environmental Factor	**Impact Assessment**	**Comment**	**Nominal/Degraded**
		batteries available for [x]days. Material can be resupplied.	
radiation	No radiation exposure in facility	Facility is located outside the radiation controlled area	Nominal
noise	SFMS DG operation may be noisy, but will not impact SFMS DG implementation	SFMS DG area walled off from crew living quarters. Within SFMS DG room, crew can wear ear protection (available in building)	Nominal
vibration	There will not be any significant sources of excess vibration and therefore will not impact the action	Operators are trained to start and run the SFMS DGs.	Nominal

A review of the above action XF-001 indicates that with the exception of the high wind environment that may accompany the event, the associated PSFs are expected to be nominal. The primary impact of this environment would be to complicate or delay transport of the staff to the SFMS facility. This was addressed by ensuring availability of a vehicle for the SMFS readying crew. As this event represents a sunny day dam failure, a high wind environment is not likely. Regardless, actions to mitigate this impact have been implemented and the impact of this potential degradation is not significant.

7.4.4.3 Human Action Timeline

Based on results of walkdown of procedure AOP-1234A as discussed in Section 7.4.4.1, the elements of the action timeline for this flood mitigation action are included in Table 7.4.4-2.

Table 7.4.4-2
Response times for Action XF-001

Time Response Component	Time (hr)	Basis
T_{delay}	0.5	Time from cue to take action for MCR to assemble crew to ready the SFMS facility. Delay time is conservatively estimated based on exercises for team selection on similar activities and site specific external flood walk-throughs.
T_{cog}	0.25	Cognition time is time the need to take action is recognized. This would quickly follow entry into the AOP. Action is immediately identified after the action to commence shutdown. A 0.25 hour duration is selected based on past experience with external flood exercises to be bounding. Experience suggests the time to reach the step to prepare the SFMS is only about 10 minutes.
T_{exe}	1	Based on results of a bounding site simulation. Includes the entire time from when the need to transition to the SFMS is recognized. Considers travel from MCR to SFMS facility. Facility is located 0.5 miles from MCR. Direct road from MCR and facility is available and road is clear from potential hazards. Need to take action and move to SFMS occurs early in the AOP. Maximum transit time is 7 minutes. Exercises performed to ready the facility indicate system alignment process may be completed in under30 minutes. One hour is conservatively allocated to the time assessment.
T_{SW}	10	Estimate based on need to complete this action prior to completing last site SFMS readiness action XF-006. Completion of XF-001 prior to that time will not delay any parallel activities. Site resources are adequate to perform all tasks and the SFMS team tasked with readying the SFMS DG involves different personnel from those tasked with XF-004 through XF-006.
T_{avail}	9.5	Time available after delay
T_{req}	1.25	Time required to perform action
T_{margin}	660%	Time Margin Available (>>100%)

7.4.4.4 Summary Feasibility/Reliability Assessment for Action XF-001

The action included in XF-001 is to prepare the SFMS for operation. XF-001 is a collection of 3 simple actions that are well trained upon. All of the action's steps are captured within one governing procedure.

An assessment of PSFs associated with the implementation of XF-001 concluded that all PSFs may be considered as nominal. A potential for high winds was identified as a potential adverse weather condition, which could lead to a degraded PSF; however the only action taken outside of building cover is traversing to the SFMS Building. In the event of extreme winds, company trucks are located at staging areas to facilitate the transport of appropriate personnel to the SFMS facility. The timing assessment used is a bounding estimate and thus takes into account a marginal (~2 mins) increase in time to complete the action due to high winds. This delay has been included in the maximum estimated transport time presented in Table 7.4.4-2. As the ability to move through the site by vehicles is available, the transport activity is judged nominal.

The timing assessments for completing the facility preparation activities were selected based on bounding timing values for completing the specified activities. The bounding timing estimates are based on the most limiting performance observed during simulations and they are not expected to be impacted by adverse conditions associated with the external flood scenario.

As discussed in Section 7.4.4.2, all PSFs associated with manual action XF-001 have been judged to be nominal. Further, the actions included in XF-001 can be completed within well within the available time window including considerations of uncertainties associated with performing this action. Therefore, the overall action is judged feasible. As a significant time margin exists in the scenario timeline, the action can be considered highly reliable.

7.4.4.5 Resource Requirements

Action requires two crew members to be dispatched from the control room. Adequate staffing is available to support this function. As skills to perform function are not unique activities may be supported by available maintenance personnel.

7.4.4.6 Conclusion

This action requires the operator to ready the SFMS for operation. Actions are clearly indicated in AOP-1234A and staff has the requisite skills and prior training. As flood waters have not reached the site at the time these actions are expected to be accomplished, all PSFs were assessed as nominal.

An assessment of the action timeline indicates that the action time window is up to 10.0 hours and the time required to complete the desired action (including staff assembly time) is estimated at 1.3 hours, indicating a time margin of 660%. As this action is well trained and is performed in a nominal environment the action is considered reliable.

7.4.X Add Additional Actions Here

8.0 Uncertainty Assessment

Uncertainty has been addressed in this evaluation through the approach selected to demonstrate high reliability of this mitigation success path. The scenario-based evaluation is described in JLD-ISG-2012-05 as, "systematic, rigorous and conservative". Therefore, the evaluation inherently considers uncertainties through the use of conservative assumptions in defining the scenario and use of bounding values for action completion times in evaluating manual actions. Although a separate explicit uncertainty analysis was not performed, the following considerations were made when determining the reliability of the strategy.

Reliability data on non-safety related flood mitigation equipment is generally not available throughout the nuclear industry, as mentioned in Section 4.3. Generic data may be available from the manufacturer and some values were included in this section, however, uncertainty in the reliability of the equipment has been handled by providing redundant equipment when important to maintaining KSFs. For example, the SFMS facility has 2 SFMS DGs, each capable of providing the same function. This provides the confidence that KSFs can be maintained despite the lack of data available on non-safety related DG failure rates or the very conservative manufacturer supplied rates. Confidence in the equipment is shown through defense-in-depth rather relying on conservative failure rates.

The human reliability analysis was also performed using the same conservative, bounding philosophy. The PSFs were evaluated using conservative assumptions for procedure cues and directions, the environmental factors where the actions are being taken and the amount of time required to successfully perform the action. Additionally, bounding times were used in evaluating the feasibility and reliability of the action. The timing analysis for all actions evaluated in Section 7 used these bounding values to account for uncertainty in the timing estimates and to demonstrate margin.

In summary, this treatment of uncertainty is appropriate for demonstrating that the mitigation strategy is highly reliable with margin. Key equipment required for successful implementation of the mitigation strategy was determined to be highly reliable accounting for uncertainties through defense-in-depth and redundant equipment. All actions were determined to be feasible and reliable through detailed evaluation in Section 7. Each analysis used conservative bounding assumptions to determine that adequate time and time margin was available throughout the scenario. These elements comprise the uncertainty analysis and demonstrate that there is high reliability and margin in successfully completing the mitigation strategy.

9.0 Conclusion for a Highly Reliable Success Path

The scenario-based evaluation has demonstrated that the mitigation strategy for a sunny-day dam breach is highly reliable and has adequate margin. The scenario success path clearly identifies the required critical components for the success of the mitigation strategy. Each critical component has received detailed, rigorous and conservative evaluations to demonstrate high reliability and margin.

The equipment required to implement the strategy has been evaluated in Sections 3 & 4. Clear descriptions on the systems and components have been provided to communicate each SSCs role in maintaining KSFs. Reliability estimates were provided, when available and redundant equipment exists for components that are critical to success.

The human actions required for success have been evaluated in detail throughout Section 7. Each action was described in detail. The procedure cues and directions were evaluated. The time required to perform each action and the amount of time available were evaluated using bounding values that account for uncertainties described in Section 8. Every actions time margin was calculated and deemed adequate for concluding that the strategy is highly reliable.

The overall strategy timeline and resource requirements were reviewed in Section 5. This section looked at all the actions required and the overall time to complete the strategy. A detailed timeline has been provided that demonstrates clear understanding of the scenario progression and responsibility of the parties performing the actions. Whether the actions are evaluated separately or in aggregate there is high confidence that the mitigation strategy will be successful and all the resources required are available.

The conclusion of the scenario-based evaluation for this mitigation strategy is that the strategy is both highly reliable and has adequate margin.

10.0 References

1. U.S. Nuclear Regulatory Commission, Japan Lessons-Learned Project Directorate (JLD) – Interim Staff Guidance (ISG) -- 2012-05. ” ML12311A214, November 30, 2012

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