19R Probabilistic Flooding Analysis

The information in this section of the reference ABWR DCD, including all subsections, tables, and figures, is incorporated by reference with the following departures and supplements.

STP DEP 1.2-2

~~STP DEP T1 2.14-1 (Figure 19R-6)~~

STP DEP T1 5.0-1 ~~(Figure 19R-6)~~

STP DEP 9.2-10 (Table 19R-1)

STP DEP 19R-1 (Table 19R-7)

STP DEP 10.4-2

19R.1 Introduction and Summary

The following site-specific supplement presents the analysis performed for the RSW pump house internal flood.

The ABWR has been designed to withstand the effects of postulated flooding internal to the plant. This appendix discusses the capabilities of the ABWR to withstand internal flooding (e.g., service water, suppression pool line breaks).

Results of the ABWR probabilistic flood analysis show:

(1) The only buildings where potential flooding could damage safety-related equipment or cause plant transients are the turbine, control, service and reactor buildings, and the Reactor Service Water (RSW) pump house*. The radwaste building does not contain safety-related equipment and flooding cannot affect safety-related equipment in other buildings. Failure of seals in the radwaste tunnels between buildings was determined to result in several orders of magnitude lower core damage frequency than direct flooding due to pipe breaks in each building and was not included in the flooding event trees.*

(2) The flood concern for the turbine building is water filling up the condenser pit and flowing into the service building tunnel which is the access path to the reactor and control buildings. The reactor and control buildings contain safe shutdown equipment. The turbine building has the potential to be flooded by two unlimited sources: circulating water and turbine service water. The condenser pit contains redundant water level sensors (in a two-out-of-four logic) which send an alarm to alert the operator to potential flooding and automatically trip the circulating water system (CWS) pumps and close CWS isolation valves. In the unlikely event this automatic protection fails and the operator fails to take any action, potential flood waters would still be prevented from reaching the service building. Potential flood waters would be

expected to exit the turbine building through the non-watertight truck entrance door. Also, there is a normally closed and alarmed door separating the turbine and service building access tunnel. If this door were to open due to water pressure from the flood, watertight doors at the entrances to the reactor and control buildings from the service building should prevent damage to safety-related equipment. Turbine service water (TSW) breaks must be manually mitigated by either tripping the pumps, or closing valves, or opening the truck entrance door. Sufficient time is available to complete these actions (greater than several hours) due to the relatively low TSW flow and the large size of the turbine building. CWS breaks dominate the CDF so no TSW event trees were completed. Thus, no impact on plant safety is expected from potential turbine building flooding. The estimated core damage frequency from turbine building flooding is extremely small for a plant with a low power cycle heat sink (PCHS) and is slightly higher for a high PCHS.

(3) *The control building could potentially be flooded by the ~~reactor building service water (~~RSW~~)~~ system which is an unlimited source or by breaks in the Fire Water System. The control building has six floors but floor drains and stairwells would direct all potential flood waters to the bottom floor where the safety-related reactor building cooling water (RCW) system components are located. There are three divisions of RCW/RSW in physically separate rooms with watertight doors.*

The RCW/RSW rooms in the control building lower level contain two sets of water level sensors in each division in a two-out-of-four logic. The first set of sensors send an alarm signal to the operator at 0.4 meter. The second set of sensors are actuated at 1.5 meters and send an alarm signal to the operator and trip the RSW pumps and close RSW system isolation valves in the affected division. Water remaining in the lines between the control building and the ultimate heat sink could be ~~siphoned or~~ drained *into the control building. The water pumped into the control building prior to isolation of the RSW system and the water drained in from the RSW line outside is limited to affecting only one RCW division. The two other safety divisions (or alternate means) would remain undamaged and able to be used to achieve safe shutdown if necessary. The estimated core damage frequency from RSW flooding is extremely small.*

Fire Water System breaks could cause flooding in all three safety divisions on a given floor since doors separating the divisions do not have sills. Floor drains and other floor openings in all three divisions ensure that postulated fire water breaks, if unisolated, will be directed to the first floor. The CDF for fire water flooding in the Control Building is extremely small.

The total control building flooding CDF is extremely small.

(4) *The reactor building is adequately protected from flooding concerns by the following:*

(5) The RSW pump house could also be potentially flooded by breaks in the RSW system, which is an unlimited source of water from the Ultimate Heat Sink (UHS). The RSW pump house has two floors, the pump room floor at elevation (-) ~~22~~18 ft, and the electrical and HVAC room at elevation 14 ft, and is divided into three physically separate sections, by 3 hour fire-rated concrete walls and 3 hour fire-rated watertight doors between the pump rooms and between the electrical and HVAC rooms. The watertight doors provide emergency and maintenance access to the rooms on each level. The watertight doors are capable of withstanding full flood pressure in either direction, and are alarmed at a security alarm station if open, and in the Control Room if not dogged closed.

The roof of the RSW pump house is at elevation 50 ft, which is above the site Design Basis Flood level. There are no openings into the RSW pump house below 50 ft. The entrance to the RSW pump house is from the roof.

Within each RSW pump rooms, two lines from the UHS, at approximately 11 ft elevation, supply water to the two, horizontal RSW pumps in each division through a normally open, locked open, manual valve. After the RSW pump, the associated RSW strainer, and the pump discharge isolation motor operated valve (MOV), the RSW supply lines combine into a single supply line per division with a division isolation MOV. RSW then passes into the divisionally separated RSW tunnel to supply the RSW/RCW heat exchangers in the basement of the Control Building. Return from the RSW/RCW heat exchangers enters the associated divisionally separated RSW tunnel, enters and passes through the RSW pump room, the return isolation MOV, and discharges to the UHS basin above the UHS operating water level.

The RSW supply line to each RSW pump is designed in accordance with break exclusion criteria, which eliminates pipe stress as a potential failure mechanism. In addition, UHS water is treated to minimize the effects of corrosion and fouling and the reinforced concrete wall common to the UHS basin and RSW pump house is designed with reduced allowable stresses to minimize the potential for concrete cracking.

Two sets of water level sensors in each division pump room are arranged in a two-out-of-four logic. The first set of sensors end an alarm signal to the operator at 0.4 meter. The second set of sensors are actuated at 1.5 meters and send an alarm signal to the operator and trip the RSW pumps and close the RSW motoroperated isolation valves in the affected division. The RSW line before the automatic isolation valve in the pump discharge is isolable with operator action to unlock and close the normally open, locked open manual suction isolation valve.

With an unisolable break in a RSW line, the pump room will flood, the electrical and HVAC room above the pump room will flood, and water will exit the RSW pump house through HVAC ventilation intake and discharge penetrations in the roof of the RSW pump house (one set for each division) disabling the associated RCW and essential core cooling system division. The other two safety division (or alternate means) would remain undamaged and able to be used to achieve safe shutdown. The estimated core damage frequency from RSW pump house flooding is extremely small.

Fire Water System breaks could cause flooding in a single RSW division, but the division separation described above serves to limit the effects of Fire Water System breaks to that RSW division. The expected flood effects from fire water system breaks in a single RSW division are not expected to be as severe as the RSW piping breaks analyzed because the flow rates are significantly less allowing more time for operator action to stop or reduce the flow. The core damage frequency for fire water flooding in the RSW pump house is extremely small.

The total RSW pump house flooding core damage frequency is extremely small.

(6) ~~*(4) The total RSW pump house flooding core damage frequency is extremely small.*~~ *The estimated total core damage frequency from internal flooding is very small for a high PCHS. This low risk level is attributable to the relatively low probability of large internal floods and the physical separation of certain safety equipment in the ABWR design. It is highly unlikely that a single flood can result in loss of more than one safety division. Where there is a potential for large flood sources to affect equipment in more than one division, instrumentation for detecting the flood and isolating the flood source is provided. The two remaining safety divisions and alternate core cooling and decay heat removal features (e.g., AC independent water addition, power conversion system) give high assurance of achieving safe shut down.*

19R.3 Screening Analysis (Water Sources and Buildings)

In order to focus the flooding analysis on buildings and water sources that have the potential to cause flooding concerns, a screening analysis was completed to eliminate sources and buildings that, for various reasons, do not require further analysis.

The screening analysis was carried out for each of the buildings. From a safe shutdown perspective, the radwaste building does not contain any equipment that is required for safe shutdown and because of physical separation, flooding cannot affect safe shutdown equipment in other buildings. Therefore, the radwaste building was not evaluated further for flooding concerns. Failure of seals in the radwaste tunnels between buildings was determined to result in several orders of magnitude lower core damage frequency than direct flooding due to pipe breaks in the buildings and was not included in the flooding event trees. Adequacy of these seals should be confirmed by the COL applicant. The turbine building does not contain any safe shutdown equipment but a flood could cause a turbine trip which is an accident initiator. Also, the turbine building is next to the service building which is the access to the reactor and control buildings and so flooding between the two buildings must be considered. The reactor and the control buildings, and the RSW pump house *contain safe shutdown equipment (e.g., RHR, RCIC, HPCF, RSW, Class 1E batteries). The flooding analysis* *will thus focus on the turbine, control, service and reactor buildings*, and the RSW pump house, *all of which either contain safety-related equipment or where flood damage could result in plant transients.*

19R.4 Deterministic Flood Analysis

The following site-specific supplement presents the analysis performed for the RSW pump house internal flood.

This subsection summarizes the physical design features of the ABWR that are capable of mitigating the effects of potential floods. A more detailed discussion of ABWR flooding features is contained in Tier 2 Subsection 3.4. The analysis will focus on the turbine, control, and reactor buildings, and the RSW pump house.

19R.4.2.4 Watertight Doors

STP DEP T1 5.0-1

The following site-specific supplement presents the analysis performed for the RSW pump house internal flood.

ECCS equipment rooms on the first floor of the reactor and control buildings, the RSW pump rooms, and the RSW electrical and HVAC rooms *have watertight doors. Also, external entrances to the control and reactor buildings below* flood *level* (Refer to Section 3.4) *have watertight doors.* The external entrance to the RSW pump house is above the design basis flood level. *The entrance to other divisional rooms have fire rated doors. These doors are normally closed and are included in the security surveillance system. These doors can be opened only with a card key and if left open security personnel will be alerted immediately. This system gives high assurance that the divisional separation will not be breached due to a door being inadvertently left open. The alarm system can detect if a watertight door is closed but not if it is dogged.* The watertight doors in the RSW pump house are alarmed in the Control Room if the door is not dogged. *A once per shift walkdown will ensure that watertight doors remain dogged when not in use.*

19R.4.2.5 Floor Drains

The following site-specific supplement presents the analysis performed for the RSW pump house internal flood.

The reactor and control buildings, and the RSW pump house *contain floor drains to direct potential flood waters to rooms where sumps and sump pumps are located. The drain system is sized to withstand breaks in the fire water system which is the most probable flood source for these two buildings. Sizing of the drain system will include provisions for plugging of some drains by debris.*

19R.4.3 Turbine Building Features

STP DEP 1.2-2

There is no safety-related equipment located in the The *turbine building. It is included as part of the detailed flood analysis because it contains non safety-related equipment (e.g., condenser, condensate pumps) that could be used to achieve safe shutdown if required, a turbine building flood could result in a turbine trip which is a transient initiator, and because it is connected to the control and reactor buildings through the service buildings access tunnel. Since the control and reactor buildings contain safety-related equipment, interbuilding flooding must be addressed.*

STP DEP 10.4-2

If either the circulating or turbine service water systems were to develop a leak and flood the turbine building, several features exist to mitigate the consequences of the flood. There are four circulating water pumps and three turbine service water pumps with *three*four *circulating water pumps and two turbine service water pumps* in operation *supplying water* from the intake structure to the screenhouse *to the turbine building. Each pump has an associated motor operated isolation valve* with the isolation valve on any idle circulating water pump closed. *The condenser pit has redundant water level sensors arranged in a two-out-of-four logic. If flooding were to occur, the level sensors would alert the control room operator, trip the CWS pumps and close CWS valves. For breaks in the TSW system, adequate time (greater than 2 hours) is available for operator action to trip pumps, or close isolation valves, or open the truck entrance door.*

19R.4.4 Control Building

STP DEP 19R-1

The following site-specific supplement presents the analysis performed for the RSW pump house internal flood.

The RCW/RSW rooms contain two sets of diverse safety grade level sensors in a two out of four logic. The first set is located at 0.4 meters from the floor and is intended to alert the control room operator to investigate for the presence of water in the RCW/RSW rooms. The second set of sensors are located at 1.5 meters and informs the control room operators that a serious condition exists that needs immediate attention. In addition, the upper level sensors trip the RSW pumps and close redundant supply side *motor operated isolation valves in the RSW system of the affected division.* Redundant motor-operated valving is provided to ensure that the UHS basin water does not gravity drain to the control building.

Anti-siphon capability (e.g., vacuum breakers, air breaks) is included to prevent continued flooding in the event that the RSW pump is tripped but the isolation valves do not close. Figure 19R-2 depicts the RSW system. Given that the pumps have tripped, actuation of the anti-siphon redundant automatic isolation *capability will terminate the flood. The ABWR UHS cannot gravity drain into the control building.*

From the above, it is concluded that the only flooding concern in the control building is a leak in the RSW system that threatens the RCW system motors in the RCW/RSW

~~*rooms. If the upper level sensor alarms, it is a clear indication of a major RSW system leak in the RCW/RSW room.*~~

~~*The following assumptions are used in this "worst case" control building flood:*~~

~~*(1) The ultimate heat sink (UHS) is at an elevation higher than the control building RCW/RSW rooms such that siphoning draining of UHS water through the RSW system to the RCW/RSW rooms is possible.*~~

~~*(2) There is a maximum of 4000 meters of pipe (2000 each for supply and return) between the UHS and the RCW/RSW room which can be discharged to the RCW/RSW room following RSW pump trip.*~~

~~*(2) (3) The size of the RSW crack is about 103 cm2 (16 in2) per ANSI/ANS -58.2 and BTP MEB 3-1.*~~

~~*(3) (4) The leak occurs in the RCW/RSW room.*~~

~~*(4) (5) No operator action was assumed.*~~

~~*The results of this "worst case" control building flood are:*~~

~~*(1) A leak occurs in the RCW/RSW room with the RSW pump running and the lower level sensor alarms at 0.4 meters.*~~

~~*(2) The water level continues to rise and reaches the high level sensor. The RSW pumps in the leaking division are tripped at 1.5 meters.*~~

~~*(3) Water flows into the RCW/RSW room from the 4000 meters of RSW pipe piping outside the control building.*~~

~~*(4) No water leaves the flooded room and only one division of RCW is affected.*~~

~~*The RCW/RSW rooms contain two sets of diverse safety grade level sensors in a two out of four logic. The first set is located at 0.4 meters from the floor and is intended to alert the control room operator to investigate for the presence of water in the RCW/RSW rooms. The second set of sensors are located at 1.5 meters and informs the control room operators that a serious condition exists that needs immediate attention. In addition, the upper level sensors trip the RSW pumps and close redundant supply side motor operated isolation valves in the RSW system of the affected division.*~~

~~*Redundant motor operated valving is provided to ensure that the UHS basin water does not gravity drain to the control building.*~~

From the above, it is concluded that the only flooding concern in the control building is a leak in the RSW system that threatens the RCW system motors in the RCW/RSW rooms. If the upper level sensor alarms, it is a clear indication of a major RSW system *leak in the RCW/RSW room. ~~The following assumptions are used in this "worst case" control building flood:~~*

The following assumptions are used in this "worst case" control building flood:

(1) *~~(5)~~The ultimate heat sink (UHS) is at an elevation higher than the control building RCW/RSW rooms such ~~than~~*that draining *~~siphoning~~ of UHS water through the RSW system to the RCW/RSW rooms is possible.*

(2) *~~(6)~~There is ~~a maximum~~ approximately ~~of~~* 580 *~~4000~~ meters of pipe (*270 m*~~2000 each~~ for supply and* 310 m *return) between the UHS and RCW/RSW room which can be discharged to RCW/RSW room following RSW pump trip.*

(3) *~~(7)~~The size of the RSW crack is about 103 cm^2 (16 in^2) per ANSI/ANS-58.2 and BTP MEB 3-1.*

(4) *~~(8)~~The leak occurs in the RCW/RSW room.*

(5) *~~(9)~~No operator action was assumed.*

The results of this "worst case" control building flood are:

(1) A leak occurs in the RCW/RSW room with the RSW pump running and the lower level sensor alarms at 0.4 meters.

(2) The water level continues to rise and reaches the high level sensor. The RSW pumps in the leaking division are tripped and redundant supply isolation valves are automatically isolated at 1.5 meters.

*(3) Water flows into the RCW/RSW room from the ~~4000~~*580 *meters of RSW pipe outside the control building.*

(4) No water leaves the flooded room and only one division of RCW is affected.

19R.4.6 RSW Pump House

The following site-specific supplement presents the analysis performed for the RSW pump house internal flood.

The RSW pump house contains the safety-related RSW pumps and support equipment that could be used to achieve safe shutdown. Potential flooding of the RSW pump house could thus negatively impact the plant's ability to reach and maintain safe shutdown.

Of the two sources of water in the RSW pump house listed in Table 19R-1, the fire water system flowrate is low and the system contains a flow alarm to alert the operator to a potential flooding condition. Adequate time would be available to locate and isolate fire water system leaks before any safety-related equipment would be damaged.

The only flooding concern in the RSW pump house are potential leaks in the RSW system from the UHS, which is an unlimited source. Leaks in the RSW piping could cause flooding damage to the RSW pumps in the bottom floor and, if unisolated, the electrical and HVAC equipment in the floor above. The three RSW divisions are physically separated into watertight compartments to the roof level. Each room is equipped with a sump pump.

Two sets of water level sensors in each division pump room are arranged in a two-out-of-four logic. The first set of sensors send an alarm signal to the operator at 0.4 meter. The second set of sensors are actuated at 1.5 meters and send an alarm signal to the operator and trip the RSW pumps and close the RSW motor-operated isolation valves in the affected division. The RSW line before the automatic isolation valve in the pump discharge is isolable with operator action to unlock and close the normally open, locked open manual suction isolation valve.

From the above, it is concluded that the only flooding concern in the RSW pump house is an unisolable leak in the RSW piping that threatens the RSW motors and associated support equipment. If the upper level sensor alarms, it is a clear indication of a major RSW system leak in the RSW pump house.

The following assumptions are used in this “worst case” RSW pump house flood:

(1) The size of the RSW crack is approximately 103 cm^2 (16 in^2) per ANSI/ANS-58.2 and BTP MEB 3-1.

(2) The leak occurs in the RSW pump room.

(3) No operator action was assumed.

The results of this “worst case” RSW pump house flood are:

(1) A leak occurs in the RSW pump room and the lower level sensor alarms at 0.4 meters.

(2) The water level continues to rise and reaches the high level sensor. The RSW pumps in the leaking division are tripped at 1.5 meters.

(3) Water flows into the RSW room from the UHS.

(4) No water leaves the flooded division until it exits the HVAC supply and return at the roof of the RSW pump house. Only a single division of RSW and ECCS is affected.

From the above, it is concluded that there are no flooding concerns in the RSW pump house because most sources of water are either not large enough or leak at small enough rates that no equipment damage could reasonably occur. The only potential water source of concern is the RSW system and only one division of RSW would be affected. The reactor could be brought to safe shutdown using equipment from the other two divisions.

19R.5.2 Methodology

The following site-specific supplement presents the analysis performed for the RSW pump house internal flood.

(5) For the RSW pump house flood evaluation, the data developed to quantify the Control Building flooding is used to perform a similar bounding evaluation of the consequences of flooding in the RSW pump house.

19R.5.3 Turbine Building

STP DEP 1.2-2

The turbine building does not contain any safety-related equipment with the exception of instrumentation associated with Reactor Protection System and condensate pump motor trip circuit breakers*. ~~But~~*Although the instrumentation and the circuit breakers are located at or above elevation 19700 TMSL (59'-3 1/2" MSL) well above the internal flood level described below and the external flood level of ~~47.6'~~40.0 ft MSL and prevented from the floods, *the flooding of the turbine building can initiate a reactor trip and may impact the safe shutdown of the plant if the water reaches the control building through the service building access tunnel. There are several water sources listed in Table 19R-1 that may leak into the turbine building. Only the two unlimited water sources (circulating water and turbine service water) are capable of flooding the turbine building and threatening safety equipment in the control building.*

STP DEP 10.4-2

The following site-specific supplement addresses the STP Site being a high PCHS design and having all openings to safety-related buildings below flood level closed.

The circulating water system (CWS) has ~~three~~ four *pumps* located in the main intake structure *and each pump has an associated motor operated isolation (shutoff) valve.* All of the four pumps are normally operating. *The turbine service water (TSW) system has three pumps and three motor operated isolation valves. For ~~a~~* the *high ~~power cycle heat sink~~*PCHS *plant design* at STP 3 & 4 *(i.e., the heat sink is at an elevation higher than grade level of the turbine building), an additional isolation valve is installed in each line. All of these are classified as non-safety grade equipment. If a large pipe break develops either in the CWS or TSW piping and initiates flooding in the turbine building, it is necessary ~~either to trip all of the pumps (for a low heat sink) or~~ to close all of the valves of the associated system to terminate the flood. Four redundant ~~safety grade~~ water level sensors (operating in a two-out-of-four logic) in the condenser pit of the turbine building will generate a signal to alert the control room operator and trip all pumps and close all isolation valves in the CWS. TSW breaks must be manually mitigated but, due to the lower flow rate (Compared to CWS), sufficient time is available to trip the pumps or close isolation valves from the control room. A turbine trip and reactor shutdown will be initiated as a consequence of turbine building flooding.*

If one or more ~~pumps fail to trip or its associated~~ valves ~~fails~~ fail *to close, the water level may rise up to the top of the condenser pit and reach grade level. If the operator received an alarm from the level sensors, even though the automatic protective* *features failed, the operator could open the truck entrance door (roll up type door) to allow the flood water to exit the building. If the operator does not receive an alarm, it is assumed that insufficient time will be available for the operator to open the truck door for a CWS break before the water level would effectively cause binding of the door and prevent opening. For TSW breaks, greater than 2 hours is available to open the door.*

If the service building door fails open, the flood rate into the service building could be high enough to flood the service building to a significant level. Since the service building is the main entrance to the plant, personnel would hear or see the flood water and alert operators in the control room. Operator action could then be taken to manually ~~trip the CWS or TSW pumps or~~ close CWS or TSW valves. This is assuming that the level sensors failed but control circuitry for ~~pump trip/~~valve isolation was still available.

If these actions failed, the flood waters would fill up the service building and could potentially enter the control or reactor buildings through several external normally closed watertight doors. On the first floor of the service building there is a watertight door which allows entrance to the reactor building cooling water (RCW) heat exchanger rooms. Failure of this door could allow the flood waters to damage equipment in all three safety divisions and potentially the battery room on the next level. If the watertight door to the RCW rooms does not fail, the water level would rise up in the service building to the next level where there are two watertight doors, one to the battery rooms of the control building and another to the reactor building clean access area. Failure of the watertight door to the battery rooms is assumed to result in core damage as loss of all DC (batteries and battery chargers) will occur. DC power is required for control of safe shutdown systems or to depressurize and use non-safety-related makeup sources such as condensate or AC independent water addition systems. Failure of the watertight door to the reactor building clean access area could result in damage to all three electrical divisions. If none of these watertight doors fail, flooding could continue to the next level where a ~~normally open~~ watertight door, normally closed except for routine ingress and egress, allows access to the control room area. Given the extensive flooding which had occurred to this point, the operators would have sufficient time and warning to ensure that ~~close~~ this watertight door is closed. If the door failed or the operators failed to close it, no core damage should occur because automatic initiation of safety systems such as the high pressure core flooder would ensure that the core remained covered with water. Continued flooding would then reach grade level where the water could exit the service building through the main entrance. It is assumed that failure of any of the external watertight doors (except the control room door) results in core damage.

Figures 19R-7 and 19R-8 are event trees which describe the turbine building flooding for low and high Power Cycle Heat Sink (PCHS) configurations, respectively. Note that Figure 19R-7 does not apply to STP 3 & 4 because they are a high PCHS design as described in Section 2.4S.1.1. *The accident progression due to a large pipe break in the CWS (the worst case flooding) is described in the event tree. As the CWS break is bounding, no TSW flooding event trees were developed. The success or failure of each flood mitigating feature in the event tree diagram may have a significant impact on the* *result of accident progression. The event trees in Figures 19R-7 and 19R-8 are described as follows:*

(2) *Four redundant ~~safety-grade~~ water level sensors (operating in two-our-of-four-logic) in the condenser pit of the turbine building detect and alert control room operators about flooding (detection).*

(3) *The bus breaker and/or pump breakers of CWS pumps open and trip all three* operating *pumps ~~(flooding prevention for low PCHS). Although siphoning could occur if the PCHS was higher than the bottom of the condenser pit, the siphon could not cause flooding to grade level. Therefore, the flood would be contained within the turbine building.~~ In case of* the *high PCHS* design of STP 3 & 4, *~~the success probability of~~ this feature is* not credited for turbine building flood mitigation *~~assumed to be zero~~.*

(4) *CWS isolation valves close ~~(flooding prevention for high or low PCHS)~~.*

(8) *The control room operator can prevent flood damage to safety-related equipment by manually ~~tripping the CWS pumps or~~ closing the* CWS *valves. It is assumed that if automatic features failed (given that the sensors did not fail) that control room actuations would also fail. If the sensors failed though, it may be possible to manually close the valves or trip the pumps from the control room once the operator is aware of the flooding condition. The probability of success is higher if the sensors did not fail because the operator would receive two indications of flooding: early in the scenario from the sensors in the turbine building and later from personnel in the service building if the flood were to propagate to that point. In either case, the watertight doors in the control and reactor buildings can prevent damage to safety-related equipment.*

~~The description of flooding for a high PCHS is the same as for a low PCHS except that the pump tripping feature is not credited.~~

The core damage frequency for turbine building flooding is extremely small for a low PCHS and slightly higher for a high PCHS design of STP 3 & 4*.*

19R.5.4.1 RSW Line Breaks

STP DEP 19R-1

The RSW system is the only unlimited water source that could cause substantial flooding in the control building (Table 19R-1). It is highly unlikely that RSW flooding could damage more than one safety division. But the occurrence of several unlikely random failures and operator errors could result in flooding damage to equipment in all three RCW divisions.

The safety-related RCW motors are located on the -8,200 mm elevation (the lowest level of the control building) in three RSW/RCW rooms which are physically separated *from each other by concrete walls and watertight doors. Each RSW/RCW room is also equipped with a sump pump.*

Each of the three RSW divisions has two safety grade pumps and *safety grade motor operated isolation (shutoff) valves~~, and anti-siphon capability (e.g., vacuum breaker)~~ (Figure 19R-2). During normal operation, one pump in each ~~divsion~~*division *is operating and the other pump is in standby. If a large leak or a pipe break develops in any one of the RSW/RCW rooms, tripping the pump and closing the associated valves in the affected division will stop the flooding. If the RSW pump trips* and*~~but~~* one *isolation valve~~s~~ fail*s *to close, ~~then~~ the* redundant set of isolation valves *~~anti-siphon capability~~ prevent continued flooding. Four redundant safety grade water level sensors (operating in a two-out-of-four logic) at the lower level (0.4 meter) of the control building will generate a signal to alert the control room operator. If the control room operator fails to take appropriate action to stop the water flow, the second set of level sensors will actuate when the water reaches the 1.5 meter level of the room. At this level, the sensors (operating in two-out-of-four logic) not only send an alarm signal to the operator but also trip the affected RSW pump and close all the isolation valves. The upper level sensors are diverse from the lowest level sensors.*

19R.5.6 RSW Pump House

The following site-specific supplement presents the analysis performed for the RSW pump house internal flood.

The RSW pump house contains the safety-related RSW system, which is used to remove the heat from the RCW heat exchangers. The RSW pump house could potentially be flooded by the RSW system which is an unlimited water source. Unisolated breaks in the fire water system could cause inter-divisional flooding since the RSW divisional separation splits the RSW pump house into three, watertight compartments. Watertight doors separate the RSW divisions.

19R.5.6.1 RSW Line Breaks

The UHS is an unlimited water source that could cause substantial flooding in the RSW pump house (Table 19R-1). It is highly unlikely that RSW flooding could damage more than one safety division. But the occurrence of several unlikely random failures and operator errors could result in flooding damage to equipment in all three RSW divisions.

The safety-related RSW pump motors are located on the lowest level of the RSW pump house in three RSW pump rooms which are physically separated from each other by concrete walls and watertight doors. Each RSW pump room is also equipped with a sump pump.

Each of the three RSW divisions has two safety grade pumps, safety grade discharge MOVs, a common header supply and return MOV and manually operated, normally open and locked open pump suction isolation valves. During normal operation, one pump in each division is operating and the other pump is in standby. If a large leak or a pipe break develops in any one of the RSW rooms, tripping the pump and closing the associated MOVs in the affected division will stop the flooding if it is downstream of the pump discharge MOV or in the RSW return line to the UHS. If the break is upstream of the RSW discharge MOV, the break is unisolable without operator action to close the manually operated suction isolation valves. Four redundant safety-grade water level sensors (operating in a two-out-of-four logic) at the lower level (0.4 meter) of the RSW pump room will generate a signal to alert the control room operator. If the control room operator fails to take appropriate action to stop the water flow, the second set of level sensors will actuate when the water reaches the 1.5 meter level of the room. At this level, the sensors (operating in two-out-of-four logic) not only send an alarm signal to the operator but also trip the affected RSW pump and close all the isolation valves. The upper level sensors are diverse from the lower level sensors.

It is assumed that one division of RSW is lost in the event of flooding in the RSW pump room. Failure of the watertight doors between the RSW divisions will allow the flood water into a second, or third RSW pump room. Failure of all RSW pump rooms will require core cooling from the power conversion system or the AC independent water addition system (ACIWA).

A large pipe break in the RSW supply line in the RSW pump room is considered to be the worst case flooding in the RSW pump house. The description of events follows:

(1) A large RSW pipe break occurs in an RSW pump room (flooding initiator).

(2) Four redundant safety grade water level sensors located at the 0.4 m level detect and alert the control room operator about flooding (detection).

(3) The operator investigates the presence of water and isolates the flooding by tripping the affected pump and/or closing the manually operated suction isolation valve (flooding prevention).

(4) If the first level of detection fails or the operator fails to isolate the flowing water, then water continues rising in the room and the second set of diverse sensors located at 1.5 meters detects the water and trips the affected pump and closes the five automatic motor operated valves in the RSW division. Meanwhile the signal alerts the control room operator of the flooding condition (flooding prevention).

(5) If the operator is successful in isolating the flooding, one safety division is assumed lost, otherwise the loss of all three safety divisions may occur (flooding mitigation).

(6) In the unlikely event that the flood is not mitigated by automatic means or operator action, the water rises to the electrical and HVAC room and floods the entire RSW compartment. Water exits the compartment through the HVAC intake and discharge vents.

(7) Failure of a watertight door at the pump room or the electrical and HVAC room could allow a second division of RSW to become flooded.

(8) Common cause failure of multiple watertight doors will disable the entire RSW system, forcing the plant to rely on the Power Conversion System and the ACIWA.

(9) Reactor safe shutdown using available equipment (reactor shutdown).

The core damage probability for an RSW pump house flood is estimated to be extremely small.

19R.6.1 Results

The following site-specific supplement presents the analysis performed for the RSW pump house internal flood.

The results from the ABWR probabilistic risk analysis are shown in Table 19R-6 for the turbine, control and reactor buildings, and the RSW pump house*. This conservative bounding analysis shows that the CDF for internal flooding is very small and is less than the total plant CDF.*

19R.6.2 Insights Gained from Analysis

STP DEP 19R-1

The following site-specific supplement presents the analysis performed for the RSW pump house internal flood.

Completion of the ABWR probabilistic flooding analysis has led to the following insights on the flooding mitigation capability of the ABWR:

(1) The ABWR due to its basic layout and safety design features is inherently capable of mitigating potential internal flooding. Safety system redundancy and physical separation for flooding by large water sources along with alternate safe shutdown features in buildings separated from flooding of safety systems give the ABWR significant flooding mitigation capability. Also, fire protection features such as floor and wall penetrations and fire barriers help to contain potential flood sources.

(2) Due to the inherent ABWR flooding capability discussed above, only a small number of flooding specific design features must be relied on to mitigate all potential flood sources. The flood specific features are: watertight doors on control and reactor building entrances, ECCS rooms, and RCW rooms, and all levels of the RSW pump house*; floor drains in reactor and control building; RSW pump trip,* redundant *isolation valve closure* ~~*and actuation of anti-siphon capability*~~ *on high water level in the RCW rooms* or RSW pump rooms; *CWS pump trip and valve closure on high water level in the condenser pit; and sump overfill lines on floor B1F of the reactor building.*

(3) All postulated floods can be mitigated without taking credit for operation of sump pumps.

(4) *While timely operator action can limit potential flood damage, all postulated floods can be adequately mitigated (from a risk perspective) without operator action.*

19R.6.4 Operator Actions

STP DEP T1 5.0-1

~~The following site-specific supplement addresses the STP design that has all openings to safety-related buildings below flood level closed.~~

(4) Ensure that the ~~*Close*~~ *watertight door at* the *entrance to the control room area* is closed *if floods in the turbine building result in service building flooding.*

The following site-specific supplement presents the analysis performed for the RSW pump house internal flood.

(6) A leak in the RSW supply line before the manually-operated, locked open suction isolation valve cannot be isolated. This line is designed to break exclusion criteria which minimizes the likelihood of a major failure or leak.

In the PRA, operator action of responding to a flood alarm has been modeled. Floods in the turbine, control and reactor buildings, or the RSW pump house *result in alarms in the control room. It is assumed that flood procedures exist and operators are well trained to respond to flooding events. The operator failure probability depends upon the time available for taking action and are conservative values based on engineering judgment. The operator actions are not important in the sense that automatic actions will prevent core damage. However, timely operator action could limit the consequences of flood events.*

19R.6.6 Conclusions

The following site-specific supplement addresses the STP site being a high PCHS design.

The conclusions from the ABWR probabilistic flooding analysis is that the risk from internal flooding is acceptably low. The estimated core damage frequency from all internal flood sources is very small for a low PCHS and slightly higher for ~~a~~ the *high PCHS* design of STP 3 & 4.

19R.7 External Flooding Evaluation

STP DEP T1 5.0-1

~~The following site-specific supplement summarizes the external flooding analysis performed for the STP site and addresses departure STP DEP T1 5.0-1.~~

Summarized in the sections below is the external flooding PRA analyses for the STP 3 & 4 plants. External flooding is defined as intrusion of water from sources outside of plant buildings such that the ability of the plant to achieve safe shutdown is affected. The analysis determined the potential core damage frequency (CDF) that could result from external flooding events for each of the new units and was developed assuming that the watertight door providing normal access to the main control room is open. This assumption provides a conservative and bounding assessment of risk from external flooding ~~because the watertight door to the main control room would be closed except for intermittent ingress and egress (Refer to FSAR Section 2.4S.10)~~.

19R.7.1 Methodology

STP DEP T1 5.0-1

To develop the external flooding analysis for STP 3 & 4, the following steps were performed:

- Identification and screening of external flooding initiating events.
- Quantification of external flooding initiating event frequency.
- Analysis of external flooding accident sequences and development of event trees.
- Quantification of external flooding core damage frequency.

Details of these steps are provided in the subsections that follow.

19R.7.2 Identify and Screen Initiating Events

STP DEP T1 5.0-1

External flooding at the STP site potentially can be initiated by several basic sources: river flooding which includes ice flooding, upstream dam breaks and landslides, tsunamis, hurricane surge, intense rainstorms, and onsite sources including Main Cooling Reservoir breach and failure of an ultimate heat sink (UHS). Events from these sources could, potentially, be related. For example, a storm could cause both a breach of an upstream dam and local flooding at the site. These correlated flooding events are analyzed in Section 2.4S of this application. This analysis considers independent and correlated flooding events.

Ice flooding of the Colorado River adjacent to the STP site is not considered a potential hazard because the warm temperatures of the area and the tidal effects that are felt on the river in the area. Therefore, ice flooding is ~~screened~~excluded as a potential initiating event.

Based on analysis performed for STP 1&2 (Reference ~~19R.7-1~~19R-1), landslides are not considered a threat to the STP site. Therefore, landslides are ~~screened~~excluded as potential external flooding initiating events.

Analysis for STP ~~1 and 2~~ Units 3 and 4~~(Reference 19R.7-1) also~~ concluded that tsunamis cannot affect the site. Therefore, tsunamis are ~~screened~~excluded from consideration as initiating events.

The storm surge or seiche resulting from a hurricane could potentially cause flooding at the STP site. However, the maximum water level at the STP site that would be expected from such an event would be elevation ~~26.74~~31.1 feet. Since this elevation is below grade level, hurricane storm surge or seiche ~~can be~~is excluded as an external flooding initiating event.

~~Intense precipitation can result in flooding local to the STP site because plant buildings will be constructed so that all external entrances are at least one foot above the flood level expected from a probable maximum precipitation event. Since the maximum flood level expected from intense precipitation is one foot below grade level for Units 3 and 4, intense local precipitation is screened from consideration as an external flooding initiating event.~~Section 2.4S.2.3 of this COLA determined the maximum height of floodwater from a probable maximum precipitation (PMP) event at 36.6’ MSL. Section 2.4S.4 identifies the grade at the center of the site as 36.6 dropping to 32’ at the perimeter of the site. ANS 2.8-1992 (Reference 19R-4) defines PMP as the estimated depth of precipitation for a given duration, drainage area, and time of year for which there is virtually no risk of exceedance. Using example methodology of Appendix B to ANS2.8-1992, floods from PMP events that potentially challenge safety-related SSCs are screened from further consideration due to the very low frequency of exceedance. The results of intense precipitation events that approach the PMP depth are bound by the design basis flood level of 40.0’ MSL based on the MCR breach analysis.

The normal operating elevation is 26 feet for the essential cooling pond (ECP) of Units 1 and 2. Since this elevation is below the nominal grade elevation for the STP site, failure of the ECP is excluded as an external flood initiating event.

The UHS basin for each unit contains a large volume of water. The 6 ft. thick reinforced concrete walls of the UHS basins are designed for seismic and other design basis loadings. However, in the event of a postulated failure of the wall the water in the UHS basin above the ground elevation can escape and flood the surrounding areas. It is unlikely that any failure of the UHS basin walls would result in a large rapid water release. Any failures of the structure would be expected to be small such that site drainage systems would be capable of preventing the water from reaching other safety-related buildings onsite. Therefore, failure of the UHS is screened from further consideration as an external flooding initiating event.

The STP site is located on the Colorado River at river mile 16.4, upstream from the Gulf of Mexico. The potential for dams upstream of the site to cause plant flooding was evaluated as part of the original licensing for Units 1&2. The analyses for Units 1&2 (Reference ~~19R.7-1~~19R-1) for failure of Mansfield dam show that a maximum flood level of 32.0 ft MSL is expected at the STP site from a single upstream dam break. Since this level is below the elevation of Unit 3&4 plant buildings, single upstream dam breaks can be screened from further consideration as external flooding initiating events.

Section 2.4S.3 of the COLA determined the maximum height of floodwater from a probable maximum flood (PMF) event on the Colorado River at 26.1 ft MSL. The still water elevation of this event is lower than the still water elevation for the multiple cascading dam flood event of 32.5 ft MSL, so no wave runup was determined in 2.4S.3. As the water level from the PMF event is lower than the multiple cascading dam failure flood event, the PMF on the Colorado River is screened from further analysis.

In addition the potential flooding effects from multiple, cascading failures of Colorado River dams upstream of the STP site has the potential to affect safety-related structures. ~~That~~The analysis described in Chapter 2.4S.4.3.1 shows ~~that~~ a peak still water elevation of ~~34.1 feet with wave runup to the 43.7 foot elevation. Therefore~~32.5 ft MSL and a wave runup of 1.9 ft for a resulting flood elevation of 34.4 ft MSL. As the building entrances are above this water level, multiple, concurrent dam failures are not considered as an external flooding initiating event.

The Main Cooling Reservoir (MCR) is formed by a 12.4 mile, earth filled embankment enclosing 7,000 acres of surface area at a normal operating level of 49.0 MSL with a capacity of 175,000 acre feet. The embankment, about 2100 feet south of the south face of the plant power block, rises an average of 40.0 feet above the natural ground surface. Breach of the MCR produces the critical flood levels at the STP site. Therefore, MCR failure is considered as an external flooding initiating event.

19R.7.3 Quantification of External Flooding Initiating Event Frequency

STP DEP T1 5.0-1

The analysis of the frequency for MCR failures begins with the frequency developed as part of the Unit 1&2 IPEEE analysis. That value has been updated to reflect MCR operating experience since completion of the IPEEE. The initiating event frequency for MCR failures that could impact Units 3&4 is determined to be very low.

~~The frequency of multiple, concurrent upstream dam breaks considers the failure of three dams, the S. W. Freese, Buchanan, and Mansfield Dams. The analysis assumes that the first dam failure can occur randomly and that the second and third failures are dependent on the previous dam failures. The sequence of events analyzed begins with failure of the S. W. Freese Dam which began operation in 1990.~~

~~Downstream of the S. W. Freese Dam is the Buchanan Dam. It is assumed that failure of the Buchanan Dam is dependent on the failure of the S. W. Freese Dam. Table 19R-4 gives values for common cause factors. Although not considered a common cause failure in the traditional sense, the second and third dam failures are analyzed using the common cause factors from Table 19R-4. Using the Beta factor from Table 19-4, failure of the Buchanan Dam, given failure of the S. W. Freese Dam is calculated.~~

~~Failure of the third dam, the Mansfield Dam, given failure of the first two dams, is calculated using the Gamma factor given in Table 19R-4. The frequency of multiple concurrent dam failures considered as external flooding initiating events is calculated to be very low.~~

The UHS is waterproof up to the site design basis flood level. As there are no openings in the Cooling Tower or the RSW Pump House below the site design basis flood level, the UHS is screened out from the consideration of flooding caused by the design basis flood.

19R.7.4 Accident Sequence Analysis

STP DEP T1 5.0-1

The subsection~~s~~ that follows summarizes the accident sequence analysis for the ~~two~~one event~~s~~ considered as an external flooding initiating event~~s~~.

19R.7.4.1 Main Cooling Reservoir Breach

STP DEP T1 5.0-1

Note that this analysis is developed assuming that the watertight door providing normal access to the main control room is open. This assumption provides a conservative and bounding assessment of risk from external flooding ~~because the watertight door to the main control room would be closed except for intermittent ingress and egress (Refer to FSAR Section 2.4S.10)~~.

A breach of the main cooling reservoir could occur suddenly or progress over many minutes. A discussion of previous dam breaches notes that the failure time of most breaches is 15 minutes to one hour from the time of inception to completion of the breach. However, some breaches became fully developed in as little as 6 minutes while others took more than 7 hours. It was also noted that half the breaches identified occurred in less than 1.5 hours. Therefore, it is concluded that, while there is a good deal of uncertainty and variability associated with the breach time, 15 minutes to one hour would likely be conservative. Breach width was also noted to be typically 2 to 5 times dam height (Reference ~~19R.7-2~~19R-2). The timing of the breach along with the width of the breach affects the height of water that reaches plant buildings. Smaller breaches or breaches that take longer to develop would result in a lower level of water on plant buildings. For smaller and slower-developing breaches, it can be expected that water would not rise above grade elevation on plant buildings. For larger and faster-developing breaches, water level on plant buildings would be higher. The analysis, originally documented in the IPEEE of Units 1&2 (Reference ~~19R.7-3~~19R-3), considered that failures of the MCR are equally likely to occur anywhere along the perimeter and excluded from consideration that portion of MCR failures that would direct water away from plant buildings. MCR failures that would result in water flowing away from the site would not be considered as external flooding initiating events, consistent with the analysis presented in Reference ~~19R.7.3~~19R-3. This assumption is considered reasonable since the land around the ~~MRC~~MCR generally slopes southward towards the Colorado River. This analysis assumed that any breach of the main cooling reservoir that is included in the initiating event definition is sufficiently large that water level will rise above the entrances to plant buildings. This analysis also assumed that the main cooling reservoir breach would cause a loss of offsite power either because of failure of the switchyard equipment or the plant auxiliary transformers that are impacted by the floodwaters. Furthermore, this analysis assumed that the loss of offsite power is not recoverable for several days.

A breach of the main cooling reservoir would cause water to flow across lighted roadways and open areas between the main cooling reservoir and the plant. Security personnel are stationed such that they have a clear view of these areas. On seeing the developing breach or water flow, they would notify the main control room in accordance with their training and procedures.

~~External~~With the exception of the normally open access door to the control building from the service building, external access points to the control and reactor buildings are provided with normally-closed, watertight barriers or doors designed to withstand the maximum loadings of any potential main cooling reservoir breach. All these doors are alarmed at the central alarm station so it is unlikely that one would be left open. Failure of any one of these doors would allow water to enter the building and flow through drains, stairways, and non-watertight doors to the essential electrical switchgear rooms below grade. Since there are no internal watertight barriers to protect the rooms on lower elevations from water entering the upper elevations, it is conservatively assumed that failure of one of the watertight doors on the reactor building would result in core damage.

The normal access to the main control building is via the service building through a watertight door on the 2950 mm elevation. As discussed above, this analysis assumes that this door is open. The door is oriented such that water external to the control building will seal the door. In addition, there are other normally-closed watertight doors that provide access to the control building from the service building and that are located either at or below grade. Since the service building is not designed to withstand flooding, it is assumed that a main cooling reservoir breach would result in water entering the service building. If any one of the doors from the service building to the control building is not closed or fails, then water could enter the control building and cause failure of all three divisions of reactor cooling water (RCW) or DC power since these are located below grade. Since there are no internal watertight barriers to protect the rooms below grade in the control building, it is conservatively assumed that failure of one of the watertight doors on the control building would result in core damage.

The turbine building and service building are not designed to withstand the effects of a failure of the main cooling reservoir. Therefore, it is conservatively assumed that any equipment in the turbine building or service building is failed by the flooding caused by a breach of the main cooling reservoir. PRA-related equipment housed in the turbine building includes the condensate and feedwater systems and the combustion turbine generator (CTG).

When notified of a main cooling reservoir breach by security personnel, the operators in the main control room staff would ensure that the normally-open, watertight control room access door is closed. Closing this door prevents water from entering the control building. As discussed above, failure to close this door would result in submerging the control building and is conservatively assumed to result in core damage.

If the door to the main control room is closed, then the event progresses as a loss of offsite power since it is assumed that the MCR breach causes a loss of offsite power. Because of the loss of offsite power, all equipment powered from non-essential electrical buses is initially lost. The loss of offsite power would result in the EDGs starting and loading to their respective essential electrical buses. The CTG would be failed by the flood so failure of all three EDGs would result in a station blackout (SBO). For this analysis, a SBO is conservatively assumed to be non-recoverable and result in core damage.

If one or more EDG starts and loads its respective buses, then the reactor can be brought to safe shutdown using equipment powered from the essential AC buses.

The accident progression for this event tree is similar to that of a loss of offsite power. However, for the main cooling reservoir breach, it is assumed that offsite power is not recovered and that failure to insert control rods or a subsequent station blackout would result in core damage.

19R.7.4.2 ~~Multiple, Concurrent Upstream Dam Failures~~

~~STP DEP T1 5.0-1~~

~~Note that this analysis is developed assuming that the watertight door providing normal access to the main control room is open. This assumption provides a conservative and bounding assessment of risk from external flooding because the watertight door to the~~

main control room would be closed except for intermittent ingress and egress (Refer to FSAR Section 2.4S.10).

The accident progression for multiple, concurrent upstream dam failures is similar to that of the main cooling reservoir breach except for timing. Since the last dam that would fail, the Mansfield Dam, is nearly 300 miles upstream of the STP site, flood waters from that dam failure would not reach the STP site for many hours. In that time, closure of the normally open main control room access door would be assured. In addition, compensatory actions such as sandbagging or installation of other temporary flood barriers can be installed around access doors. These additional compensatory actions, however, are not quantified as part of this analysis. This analysis also assumes that the flooding that results from multiple, concurrent upstream dam failures will cause a loss of offsite power either because of failure of the switchyard equipment or the plant auxiliary transformers that are impacted by the floodwaters. Furthermore, this analysis assumed that the loss of offsite power is not recoverable for several days.

External access points to the control and reactor buildings are provided with normally closed, watertight barriers or doors designed to withstand the maximum loadings of any potential main cooling reservoir breach, a more severe event than multiple, concurrent upstream dam failures. All these doors are alarmed at the central alarm station so it is unlikely that one would be left open. Failure of any one of these doors would allow water to enter the building and flow through drains, stairways, and non-watertight doors to the essential electrical switchgear rooms below grade. Since there are no internal watertight barriers to protect the rooms on the lower elevations from water that entered the upper elevations, it is conservatively assumed that failure of one of the watertight doors on the reactor building will result in core damage.

The normal access to the main control building is via the service building through a watertight door on the 2950 mm elevation. In addition, there are other normally closed watertight doors that provide access to the control building from the service building and that are located either at or below grade. Since the service building is not designed to withstand flooding, it is conservatively assumed that the flooding that results from multiple, concurrent upstream dam failures would result in water entering the service building. If any one of the doors from the service building to the control building fails, then water could enter the control building and cause failure of all three divisions of reactor cooling water (RCW) or DC power since these are located below grade. Since there are no internal watertight barriers to protect the rooms below grade in the control building, it is conservatively assumed that failure of one of the watertight doors on the control building will result in core damage.

The turbine building and service building are not designed to withstand flooding. Therefore, it is conservatively assumed that any equipment in the turbine building or service building is failed by the flooding caused by multiple, concurrent upstream dam failures. PRA-related equipment housed in the turbine building includes the condensate and feedwater systems and the combustion turbine generator (CTG).

When notified of an upstream dam failure, steps will be taken (Refer to Section 19.9.3) to ensure that the watertight main control room access door will be closed prior to flood

~~waters reaching the STP site. Since many hours are available to effect this action and the action is simple and visually verifiable, the probability of failing to ensure closure of the door is considered sufficiently small as to be neglected. Closing this door prevents water from entering the control building.~~

~~Since the flooding is assumed to cause a loss of offsite power, all equipment powered from non-essential electrical buses would be lost. The loss of offsite power will result in the EDGs starting and loading to their respective essential electrical buses. The CTG is conservatively assumed failed by the flood so failure of all three EDGs would result in a station blackout (SBO). For this analysis, a SBO is assumed to be non-recoverable and results in core damage.~~

~~If one or more EDG starts and loads its respective buses, then the reactor can be brought to safe shutdown using equipment powered from the essential AC buses.~~

~~The accident progression for this event tree is similar to that of a loss of offsite power. However, for multiple, concurrent upstream dam failures, it is assumed that offsite power is not recovered and that failure to insert control rods or a subsequent station blackout result in core damage.~~

19R.7.5 Summary of Accident Sequences

STP DEP T1 5.0-1

The subsection~~s~~ that follows summarize the determination of the accident sequences developed for the ~~two events~~one event considered as an external flooding initiating event~~s~~. Determination of the CDF made use of the existing ABWR PRA logic models and used a process similar to that used to quantify the internal flooding events.

19R.7.5.1 Main Cooling Reservoir Breach Accident

STP DEP T1 5.0-1

Four accident sequences lead to core damage. Core damage results if any one of the top events fails. Development of each of the top events is discussed below.

IEBMCR - Breach of Main Cooling Reservoir
This Initiating Event represents the main cooling reservoir breach. This event is described above.

OCD - Operator Action To Close Control Room Watertight Access Door or RB/CB External Doors Fail
This top event represents failure of the watertight doors to prevent flood waters from entering either the control building or the reactor building. Failure of this top event can occur from two causes. First, the operators can fail to close the normally open, watertight door that provides main control room access from the service building. As described in section above, security personnel are stationed such that they will have a clear view of the area between the main cooling reservoir and plant buildings. This analysis assumes that the security staff is trained and that procedures are in place for them to alert the control room if there are indications of a breach of the main cooling

reservoir. Procedures are also assumed to be in place to direct that the main control room access door be closed immediately on notification of a potential external flooding event (Refer to Section 19.9.3). Furthermore, the analysis assumes that the area between the main cooling reservoir and plant buildings is lighted to an extent that any flow of water from a breach of the main cooling reservoir would be clearly visible to the security personnel at night.

As discussed above, development of a main cooling reservoir breach is expected to take from 15 minutes to one hour.The main cooling reservoir breach analysis described in Section 2.4S.4 was used to develop a minimum available warning time from water at the South Security Gate House, approximately El. 32.0' MSL, to water at the entrances to safety-related buildings, El. 35.0' MSL. At least 30 minutes is available for operator action to close the normally open access door between the Service Building and the Control Building once water reaches the South Security Gate House. Once the security staff notifies the control room of the breach, closing and securing the watertight door takes less than one minute. Therefore, it is assumed that a moderate and adequate amount of time is available to effect the actions to close the control room access door. Then the failure probability for this event was assigned using the values in the Standard Safety Analysis Report (SSAR) Table 19R-4.

Even if operator action to close the normally-open door is successful, failure of any one of the watertight doors that allow access to the reactor building or control building could randomly fail. Using the values in the SSAR Table 19R-4, the probability of random door failures that allow water to enter either the control building or the reactor building was calculated.

The total probability of failing to isolate the control and reactor buildings from a main cooling reservoir breach is the sum of the operator failure probability and the random door failure probability.

C - Failure To Insert Control Rods
This top event represents failure to insert the control rods on the loss of offsite power caused by the external flooding event. The probability of this event is taken from the internal events PRA models.

PO1 - SRVs Fail To Open (After Scram)
This top event represents failure of the safety relief valves (SRVs) to open after a reactor trip. The probability of this event is taken from the internal events PRA models.

SSD - Reactor Brought To Safe Shutdown Condition
This top event represents failure to bring the reactor to a safe shutdown condition. Since the main cooling reservoir breach is assumed to result in a non-recoverable loss of offsite power, this node is quantified using the existing TEO event tree sequences but accounting for the additional failures that would be caused by the flooding. Basic events that represent these additional failures were set to “True” for the quantification.

The 11 core damage sequences from TEO were quantified to produce the conditional probability of core damage given that an external flooding event occurred. The resulting probability is determined to be low.

Since failure of each of the top nodes on the IEBMCR event tree results in core damage and since each of the top nodes is independent of the others, the total CDF for a main cooling reservoir breach is the product of the initiating event frequency, the success probability of any previous nodes, and the top node failure probability. The total CDF for a breach of the main cooling reservoir is determined to be very low.

19R.7.5.2 Multiple, Concurrent Upstream Dam Failures Accident

STP DEP T1 5.0-1

Four accident sequences lead to core damage. Core damage results if any one of the top events fails. Development of each of the top events is discussed below.

IEDAM - Multiple Concurrent Upstream Dam Failures
This top event represents the failure of the three dams upstream of the STP site on the Colorado River. This event is described above.

WTDOOR - Reactor Building and Control Building External Watertight Doors Fail
This top event represents failure of the watertight doors to prevent flood waters from entering either the control building or the reactor building. Because of the long time available for notification and action following failure of the last dam on the Colorado River, it is assumed that the failure probability of operator action to close the normally open watertight door to the main control room can be neglected.

Any one of the nine watertight doors that allow access to the reactor building or control building could randomly fail. Using the values in Table 19R-4, the probability of random door failures that allow water to enter either the control building or the reactor building is calculated.

C - Failure To Insert Control Rods
This top event represents failure to insert the control rods on the loss of offsite power caused by the external flooding event. The probability of this event is taken from the internal events PRA models.

PO1 - SRVs Fail To Open (After Scram)
This top event represents failure of the safety relief valves (SRVs) to open after a reactor trip. The probability of this event is taken from the internal events PRA models.

SSD - Reactor Brought To Safe Shutdown Condition
This top event represents failure to bring the reactor to a safe shutdown condition. This top event is described in Section 19R.7S.5.1.

Since failure of each of the top nodes on the IEDAM event tree results in core damage and since each of the top nodes is independent of the others, the total CDF for an external flooding event caused by multiple, concurrent upstream dam failures is the product of the initiating event frequency, the success probability of any previous nodes, and the top node failure probability. The total CDF for a breach of the main cooling reservoir is determined to be very low.

19R.7.5.3 Total External Flooding Event CDF

STP DEP T1 5.0-1

The total CDF from the external flooding events is obtained by summing the CDF from each of the events above and is determined to be very low.

19R.7.6 Important External Flooding-Related Design Features

STP DEP T1 5.0-1

There are several design features important to minimizing external flood-related risk. One is that all buildings are constructed with entrances at least one foot above the flood level that would result from a PMP related flood. This feature allows screening of most external flooding events. Another feature is that all plant entrances and penetrations located below the maximum flood level are protected by watertight barriers or doors. Also, a clear view is provided from plant buildings to the main cooling reservoir thereby allowing for timely notification to the main control room of a main cooling reservoir breach.

19R.7.7 Operator Actions Related to External Flooding

STP DEP T1 5.0-1

One operator action is important to external flooding risk. This action, timely closure of the watertight door at the entrance to the main control room is similar to the event included in section 19R.6.4. However, the cues to initiate the action for the external flooding events areevent is different than for internal flooding.

19R.7.8 External Flooding Reliability Goals (Input to RAP)

STP DEP T1 5.0-1

The results of the external flooding analysis show that watertight doors are important to reducing external flood-related risk. Watertight doors are included as input to the RAP because of internal flooding events. The information from Section 19R.6.5 related to watertight doors is also applicable to the external flooding events and is applied to all external watertight doors on the reactor and control buildings.

19R.7.9 Conclusions

STP DEP T1 5.0-1

The conclusions from the ABWR probabilistic external flooding analysis are that the risk from external flooding is acceptably low, even with the conservative assumption that the watertight normal access door to the control room is open. The risk from external flooding would be significantly lower if analyzed assuming that the door is closed, as described in FSAR Section 2.4S.10. It is also concluded that the incremental risk from external flooding events is within the goals for an increase in CDF or LERF.

19R.8 References

The following site-specific supplement provides references.

19R-1 STPEGS 1&2 UFSAR Section 2.4, Hydrologic Engineering, Revision 13.

19R-2 "Prediction of Embankment Dam Breach Parameters," DSO-98-004, Dam Safety Office, Water Resources Research Laboratory, US Department of the Interior, Bureau of the Interior, July, 1998.

19R-3 South Texas Project Electric Generating Station Level 2 Probabilistic Safety Assessment and Individual Plant Examination, Revision 0.

19R-4 ANS 2.8-1992, Determining Design Basis Flooding at Power Reactor Sites, American Nuclear Society, 1992.

Table 19R-1 Sources of Water

Source	Capacity	Flow Rate	Turbine Building	Control Building	RSW Pump House	Reactor Building	Service Building	Radwaste Building
Reactor Service Water (RSW)	Unlimited	~~499.67~~ **675** liters/sec/~~div~~**pump**. (~~7,920~~**10,700** GPM/~~div~~**pump**.) **(6 pumps)**		X	**X**			
Turbine Service Water	Unlimited	~~12,618~~**1,278** liters/s/pump (~~15,000~~**20,255** GPM/Pump) (3 pumps)	X					
Circulating Water (CW)	Unlimited	~~12,618~~**18,927**liters/s/pump (~~200,00~~**300,000** GPM/pump) (~~3~~**4** pumps)	X					
Fire Water	1,249,182 liters/tank (330,000 gal/tank) (2 tanks)	~~9.46~~**94.6** liters/s/~~2~~ pump~~s~~ (~~150~~**2788** GPM/**pump** **(**2 pumps)	X	X	**X**	X	X	X
Reactor Building Cooling Water (RCW)	257,407 liters/div. (68,000 gal/div)	~~360.87~~**4040** liters/s (A,B) (~~5,720~~**6252** GPM (A,B) ~~305.36~~**344** liters/s (C) (~~4,840~~**5466** GPM (C)		X		X		X
HVAC Normal Cooling Water (HNCW)	113,562 liters (30,000 gal)	~~106.94~~**286** liters/s (~~1695~~**4535** GPM) **(5 pumps)**		X		X	X	X
HVAC Emergency Cooling Water (HECW)	113,562 liters (30,000 gal)	7.57 - ~~13.88~~**15.77** liters/s (120-~~200~~**250** GPM) (Chilled) 21.51-35.58 liters/s (341-564) GPM) (Condenser)		X		X	X	X

Table 19R-1 Sources of Water (Continued)

Source	*Capacity*	*Flow Rate*	*Turbine Building*	*Control Building*	RSW Pump House	*Reactor Building*	*Service Building*	*Radwaste Building*
Makeup Water (Condensate)	*2,108,468 liters (557,000 gal)*	*104.10 liters/s (1,650 GPM)*	*X*			*X*		*X*
Makeup Water (Purified)	*757,080 liters (200,000 gal)*	*19.43 liters/s (308 GPM)*				*X*		
Turbine Cooling Water (TCW)	*378,540 liters (100,000 gal)*	~~*1829.61*~~**2524** *liters/s* (~~*29,000*~~**40,000** *GPM)*	*X*					
Feedwater	*757,080 liters*	~~*2110.82*~~**2750** *liters/s* (~~*33,600*~~**43,600** *GPM)* **(4 pumps)**	*X*				*X*	
City Water Suppression Pool	*Unlimited 3,579,754 liters (947,674 gal)*	*12.62 liter/s*			*X*			

Table 19R-6 Internal Flooding Core Damage Frequency (CDF)

The following site-specific supplement states that low PCHS is not applicable to STP 3 & 4.

	CDF (per reactor year)	
Building	**Low PCHS***	**High PCHS***
Turbine	Not Applicable	
Control	Not Applicable	
Reactor	Not Applicable	
Total	Not Applicable	

* Not part of DCD (refer to SSAR).

Table 19R-7 ABWR Features to Prevent/Mitigate Flooding (Continued)

Feature	Benefit
RSW Pump House	
RSW pump rooms and electrical and HVAC rooms have watertight doors.	Prevent flooding in one division from affecting other divisions.
Watertight doors in the RSW pump house are alarmed in the Control Room if not dogged closed	Additional barrier to ensure watertight integrity between pump rooms is maintained.
Floor drains route water to first floor (RSW pump rooms).	Protects equipment in rooms from water damage and directs water to sump pumps.
RSW pump rooms have sump pumps.	Remove flood water from room to prevent damage to equipment.
RSW pump room floor water level sensors alarm at 0.4 meter and trip RSW pumps and close redundant isolation valves at 1.5 meters in affected division.	Alert operator to RSW leak and shutoff RSW supply if flooding were to continue.
RCW/RSW room floor water level sensors alarm at 0.4 meter and trip RSW pumps and close redundant *isolation valves at 1.5 meters in affected division.*	*Alert operator to RCW leak and shutoff RSW supply if flooding were to continue.*

[s1]

Figure 19R-6 Reactor Building Arrangement - Elevation 12300 mm (1F)

Figure 19R-6 is replaced by Chapter 21, Figure 1.2-8.

[e1]

Figure 19R-7 Turbine Building Flooding (Low PCHS)

The information in this figure is incorporated as a site-specific supplement to the reference ABWR DCD.

Note that this figure does not apply to the high PCHS design of STP 3 & 4. This figure is deleted.