3.4 Water Level (Flood) Design

Criteria for the design basis for protection against external flooding of an ABWR plant site shall conform to the requirements of RG 1.59. The types and methods used for protecting the ABWR safety-related structures, systems and components from external flooding shall conform to the guidelines defined in RG 1.102. The design criteria for protection against the effects of compartment flooding shall conform to the requirements of ANSI/ANS-56.11 (Reference 3.4-2).

The design basis flood levels and ground water levels for the ABWR standard plant are shown in Table 3.4-1 as specified by Table 2.0-1. For those structures outside the scope of the ABWR Standard Plant (e.g., the ultimate heat sink pump house), the COL applicant will demonstrate the structures outside the scope meet the requirements of Table 2.0-1 and GDC 2 and the guidance of RG 1.102. See Subsections 3.4.3.1, 3.4.3.2, and 3.4.3.3 for COL license information requirements.

The impact of flooding was determined by the maximum flow rate and the volume of water available to feed the break. In many cases no active response was assumed to terminate the flow and the entire volume of available water was assumed to spill into the effected building. For flood water, sources outside the building (fire, service, and ground water) automatic or operator actions are required to terminate the flow.

All flood water is assumed to ultimately accumulate in the basement of the affected building. No credit is taken for sumps removing water. Safety-related equipment located in the basement is protected by locating it in flood protective compartments and/or installing it a minimum of 200 mm above the floor. Water from breaks inside flood protected compartments is prevented from entering other flood protected compartments but may flow to non-flood protected spaces (i.e. corridors). Water from breaks outside flood protected compartments is prevented from entering flood protected compartments.

Floods initiating on other elevations are prevented from effecting more than one division of safety-related equipment. Safety-related equipment is mounted a minimum of 200 mm above the floor and spray effects are confined to a single division. Design features limit the accumulation of water to depths less than 200 mm and the floors are designed to prevent water from seeping to lower elevations other than through predetermined pathways including drains, stair towers, and elevator shafts.

The plant design has been evaluated for all potential breaks and includes design features to limit damage from flooding to a single division. The ABWR can be safely shutdown following all potential floods.

3.4.1 Flood Protection

This section discusses the flood protection measures that are applicable to the standard ABWR plant safety-related structures, systems, and components for both external flooding and postulated flooding from plant component failures. These protection measures also apply to other structures that house systems and components important to safety which fall within the scope of specific plant.

A compliance review will be conducted of the as-built design against the assumptions and requirements that are the basis of the flood evaluation presented below and Appendix 19R. This as-built evaluation will be documented in a Flood Analysis Report. The report will include an assessment and disposition of any non-compliances that are found between the as-built facility and the information in this section and Appendix 19R. The criterion for determining appropriate disposition of any non-compliance(s) will be that the final as-built facility conforms with the following flood protection characteristics and the assessment in Appendix 19R.

3.4.1.1 Flood Protection Measures for Structures

The safety-related systems and components of the ABWR Standard Plant are located in the Reactor and Control Buildings which are Seismic Category I structures. Descriptions of these structures are provided in Subsections 3.8.4 and 3.8.5. The ABWR standard plant structures are protected as required (Table 3.4-1), against the postulated design basis flood level specified in Table 2.0-1. Postulated flooding from component failures in the building compartments is prevented from adversely affecting plant safety or posing any hazard to the public.

Table 3.4-1 identifies the exterior or access openings and penetrations that are provided with features for protection against floods.

3.4.1.1.1 Flood Protection from External Sources

The safety-related components located below the design basis flood level inside a Seismic Category I structure are shown in the Section 1.2 building arrangement drawings. All safety-related components located below the design flood level are protected using the hardened protection approach described below.

Seismic Category I structures remain protected for safe shutdown of the reactor during all flood conditions.

The safety-related systems and components are flood-protected either because they are located above the design flood level or are enclosed in reinforced concrete Seismic Category I structures which have the following features:

(1) Exterior walls below flood level are not less than 0.6m thick.

(2) Water stops are provided in all construction joints below flood level.

(3) Watertight penetrations and doors between Category I and non-Category I buildings are installed below flood level.

(4) Waterproof coating is applied to external surfaces exposed to flood level, and is extended a minimum of 150 mm along the penetration surfaces.

(5) Roofs are designed to prevent pooling of large amounts of water in accordance with RG 1.102.

(6) Tunnels below grade do not penetrate exterior walls.

Waterproofing of foundations and walls of Seismic Category I structures below grade is accomplished principally by the use of water stops at expansion and construction joints. In addition to water stops, waterproofing of the plant structures and penetrations that house safety-related systems and components is provided up to 8 cm above the plant ground level to protect the external surfaces from exposure to water.

The flood protection measures that are described above also guard against flooding from onsite storage tanks that may rupture. The largest is the condensate storage tank.

This tank is located between the Turbine Building and the radwaste building where there are no direct entries to these buildings. All plant entries start 30 cm above grade. Any flash flooding that may result from tank rupture will drain away from the site and cause no damage to site equipment.

Additional specific provisions for flood protection include administrative procedures to assure that all watertight doors and hatch covers are locked in the event of a flood warning. If local seepage occurs through the walls, it is controlled by sumps and sump pumps. Deterioration of exterior building wall penetration seals will be detectable by visual seepage. Corrective actions can be taken in a timely manner to control the problem. The COL applicant will review the use of penetration seals below grade and develop procedures as necessary to protect the plant against the effects of seal failure. This review will be included in the Flood Analysis (Subsection 3.4.1) and will contain information that shows that the ability to safely shutdown the reactor and maintain a safe, cold shutdown condition is maintained because either

(1) the penetration seals are highly reliable or

(2) emergency procedures are in place to guide the plant response to a postulated seal failure followed by flooding.

In the event of a flood, flood levels take a relatively long time to develop. This allows ample lead time to perform necessary emergency actions for all accesses that need to be protected.

3.4.1.1.2 Compartment Flooding from Postulated Component Failures

All piping, vessels, and heat exchangers with flooding potential in the Reactor Building are seismically qualified, and complete failure of a non-seismic tank or piping system is not applicable.

In accordance with Reference 3.4-2, leakage cracks are postulated in any point of moderate-energy piping larger than nominal 25A size; breaks are postulated in such piping if it is a high-energy piping. The leakage flow area from a crack is assumed to be a circular orifice with flow area equal to one-half of the pipe outside diameter multiplied by one-half of the pipe nominal wall thickness. Resulting leakage flow rates are approximated using Equation 3-2 from Reference 3.4-1 with a flow coefficient of 0.59 and a normal operating pressure in the pipe.

Water spray, foaming and flooding effects in the room of the pipe crack or break are considered by conservatively assuming that a division having a pipe failure within its rooms is lost from service to bring the reactor to a safe shutdown condition. In addition, the following provisions and assumptions are made to limit the effects to one division:

(a) Divisional flood walls located on the -8200 mm elevation of the Control and Reactor Buildings are 0.6m or thicker. Watertight doors and penetrations are provided in openings below the maximum flood level to prevent water seepage or flow,

(b) Doors and penetrations rated as 3 hour fire barriers are assumed to prevent water spray from crossing divisional boundaries,

(c) Floors are assumed to prevent water seepage to lower levels,

(d) Penetrations between floors for pipe, cable, HVAC duct, and other equipment will be designed to prevent water seepage to lower elevations from 200 mm of standing water through the use of seals or curbs,

(e) In general equipment access hatches shall prevent water seepage to lower elevations from 200 mm of standing water. Hatches to filter/demineralizer compartments may not be required to prevent water seepage, and

(f) Water from a pipe break is assumed to flow under non-water-tight doors and spread evenly over the available areas. Water sensitive safety-related equipment is raised 200 mm above the floor. The depth of water on the floor is limited to less than 200 mm utilizing available floor space and limiting the availability of water volumes. Furthermore, floor drains, stair towers, and elevator shafts provide drain paths to the building basements inside secondary containment.

The MSL tunnel area is instrumented with air temperature monitors that are used to automatically isolate the MSIVs upon detection of high abnormal limits.

However, in the event of worst case flooding involving a 550A nominal pipe size feedwater line break, the maximum flow rate from this high energy line break will not exceed 3.6 m^3/min over a 2-hour period. Refer to Table 15.6-16 for feedwater line leakage parameters. Water discharged from a postulated feedwater line break will be contained in the Seismic Category I structure of the MSL tunnel area and will not flood any safety-related equipment in the Reactor Building. The flooded area will be allowed to drain through normally closed floor drains in the tunnel area which are routed to the HCW sumps in the Reactor Building for collection and discharge.

No credit is taken for operation of the drain sump pumps, although they are expected to operate during some of the postulated flooding events.

After receiving a flood detection alarm, the operator has a 10-minute grace period to act in cases when flooding can be identified and terminated by a remote action from the control room. In cases involving visual inspection to identify the specific flooding source in the affected area (except ECCS areas) followed by a remote or local operator action, a minimum of 30 minutes is provided for the operator.

In all instances of compartment flooding, a single failure of an active component is considered for systems required to mitigate consequences of a particular flooding condition. The Emergency Core Cooling System (ECCS) rooms are also evaluated on the basis of a loss-of-coolant accident (LOCA) and a single active failure or a LOCA combined with a single passive failure 10 minutes or more after the LOCA.

Considering the above criteria and assumptions, analyses of piping failures and their consequences are performed to demonstrate the adequacy of the ABWR design. These analyses are provided separately for the Reactor, Control, Radwaste, Service, and Turbine Buildings.

Analyses of the worst flooding due to pipe and tank failures and their consequences are performed in this subsection for the Reactor Building, Control Building, Radwaste Building, Turbine Building and the Service Building. No credit is taken for safety-related equipment within these structures if the equipment becomes flooded. However, in accordance with Section 3.11, all safety-related equipment is qualified to high relative humidity.

There is no need of the COL applicant information requirements upon the remainder of the plant from effects of possible flooding in the ABWR Standard Plant buildings. Lines, such as storm drains and sanitary waste lines, interface with plant yard piping. However, provisions are made in these lines that, should the yard piping become plugged, crushed, or otherwise inoperable, they will vent onto the ground relieving any flooded condition.

3.4.1.1.2.1 Evaluation of Reactor Building Flood Events

Analysis of potential flooding within the Reactor Building is considered on a floor-by-floor basis. The potential consequences of the high energy breaks in the Reactor Building are evaluated in Subsection 6.2.3.3.1.

3.4.1.1.2.1.1 Evaluation of Floor 100 (B3F)

The HCW sumps in the basement floor are the collection location points for floods routed through floor drains in the building.

Worst case flooding on this floor level would result from leakage of the RHR 450 mm suction line between the containment wall and the system isolation valve (this applies also to the HPCF, RCIC, and SPCU suction lines, although in smaller line sizes). Leakage from this source may cause flooding of the affected RHR heat exchanger (Hx) room and the neighboring ECCS room of the same division at a rate of 1.04 m^3/min and may continue until equalization of water level occurs between these rooms with the suppression pool level. Flooding in these ECCS rooms may cause loss of functions for that particular divisional system loop. This will not impair the safe shutdown capability of the reactor system. Flooding of other divisions is prevented by watertight doors with open/close status indicator lights and alarms in MCR. Suction lines to other services always remain submerged. Other flooding incidents may result from failures of other piping systems penetrating the RHR Hx rooms for each division; these events, however, upon detection by sump alarms, are controllable by terminating flow with closure of valves and shutdown of pressure sources.

HPCF and RCIC Systems, while having the susceptibility to flood their respective compartments from the suppression pool, do so at lower rates than the RHR System. Failure, however, is guarded against by watertight doors so that flooding in one division does not propagate to other divisions.

A failure in the nondivisional area involving the failure of the 200A SPCU system suction line before the isolation valve will permit flooding of the fourth quadrant and corridors uncontrollably by system elements. The flooding rate, driven by suppression pool head, would not exceed 0.27 m^3/min and, depending upon the rate of manual repair, may permit 25–30 m^3 of water to escape into the fourth quadrant. Certain functions of the SPCU, CUW, and backwash systems may be lost, but because of watertight doors on divisional areas, no essential functions would be lost and plant integrity would not be in question.

Manual firefighting on this floor will bring in 0.57 m^3/min. Such activities would not create a water depth which would cause concern.

3.4.1.1.2.1.2 Evaluation of Floor 200 (B2F)

Flooding events on this floor may result from piping failures in the RHR pipeways, or from piping systems of the HPCF and RCIC. Maximum flooding would occur from a 250A RHR pressure line at a flow rate of 1.34 m^3/min. These lines are inside pipe chases. Hence, leakage from these lines accumulates on floor 100 (B3F).

In associated divisional compartments failures of 400A RCW pressure lines may also occur. Prior to system isolation, this would result in a flooding rate of 2.8 m^3/min. A total of 27 m^3 of water are spilled.

In the fourth quadrant, SPCU and CUW F/D valve rooms, holding pumps and HNH pump and Hx rooms, may experience flooding from various system line failures. The maximum flooding will be from a 200A line at pump pressure resulting in discharge of 0.92 m^3/min. A total of 27 m^3 is spilled.

The leakage may propagate between divisions but an area of 300 m^2 is available, so that depth of less than 200 mm is maintained. No water will damage safety-related equipment. Alarming and prompt operator isolation of these systems is then performed.

Firefighting on this floor will be accomplished manually with a flow of 0.57 m^3/min. Areas of activity are rather large so that this quantity of water (less than for other events above) presents no problem.

3.4.1.1.2.1.3 Evaluation of Floor 300 (B1F)

Primary flooding events on this floor are associated with pipeways and pipechases utilized by RHR, HPCF, and RCIC Systems. Maximum leakage is that postulated for a 250A RHR pressure line failure in rooms that are connected to rooms on floor 100 (B3F). Hence leakage from these breaks accumulates on floor 100 (B3F).

Flooding in the emergency electric rooms A, B and C and the remote shutdown rooms may occur from leakage or failures in the heating and ventilating chilled water supply or emergency HVAC cooling water system. These failures are limited in potential water release by line inventory and surge tank capacity and will not exceed 8 m^3, causing a total water depth of 4–5 cm.

Equipment is raised 200 mm to prevent loss of function due to flooding until response to the failure is made.

Firefighting activity in all areas of this level are carried out by manual means at a maximum rate of 0.57 m^3/min and no greater effects than those already considered will occur.

Failures in the CUW and SPCU systems filter/demineralizers and associated piping may occur as on Floor 200 but will spread over a comparable area or drain down to Floor 200 or 100 so that adequate time is available for detection and subsequent system isolation.

3.4.1.1.2.1.4 Evaluation of Floor 400 (1F)

Flooding from the RHR, HPCF, and RCIC systems may occur in valve rooms A, B and C. Maximum flooding is a failure of the 250A RHR pressure line with leakage flow of 1.34 m^3/min. These rooms are connected to floor 100 (B3F) by pipe chases. No accumulation is expected on this floor.

The floors in the valve rooms are open gratings, open to the divisional pipe chases which lead to the divisional ECCS rooms in the basement. The valve room floor is two meters higher than the access corridor such that flooding in the corridor can not drain to the divisional ECCS areas in the basement via the divisional pipe chases.

Emergency diesel generator A, B and C rooms contain cooling water piping to components of this system. Flooding may occur from failures of 200A RCW piping serving these cooling needs at a maximum rate of 0.9 m^3/min, which will fill the floor area and escape into the corridor, with potential cascading down the stairwell. The water will spread over the side areas on the lower floor while action to isolate the failed system takes place. Equipment is raised to 200 mm to prevent loss of function due to flooding until response to the failure is made.

Leakage of lubricating oil is also possible in the diesel generator rooms, but level indication provides a continuing control on this source. Even major leakage will be contained in the subject rooms due to the small inventory of fluid available.

Firefighting in the diesel generator area will be provided by a foam sprinkler system. Other firefighting will be by hoses but will be of smaller volumes than those considered, and will be of limited duration.

3.4.1.1.2.1.5 Evaluation of Floor 500 (2F)

This floor contains the following equipment areas:

(1) The emergency diesel generator A, B, and C equipment areas including fans, control panels, air storage tanks, and associated piping.

(2) The fuel pool cooling and cleanup system consisting of two circulating pumps, two heat exchangers, two filter demineralizers, instrumentation and associated valves and piping.

(3) The SGTS monitor room.

(4) The stack monitor room.

(5) The MSL tunnel area.

Flooding may occur from failure of 200A fuel pool cooling line at a maximum rate of 0.9 m^3/min, which will fill the floor area. The water will escape down stairwells or flow down the drain system to floor 100 (B3F). Due to limited inventory, water is limited to a few centimeters in depth. Safety-related equipment sensitive to water (i.e., electrical, control, and instrumentation) will be protected by raising them at least 200 mm above the floor.

Flooding may also occur inside the steam tunnel. This water volume will be kept inside the tunnel until the operators are ready to pump it to radwaste for treatment. No safety-related equipment will be effected by this break. All valve operators are well off the floor. They are expected to act prior to their immersion by any flood.

For item (1) above, the three DG equipment areas house the exhaust fans for heating and cooling these areas. Flooding can only occur from rupture of the chilled and hot water lines to the fan coils. However, any flooding is expected to be minimal and will be contained within the affected area. The three divisional DG equipment areas are separated and mechanically isolated from each other and water intrusion from a flooded compartment is unlikely.

For item (2) above, the FPC equipment is classified non-safety-related. The only safety-related piping that connects with the FPC System belongs to RHR, which is used to supplement the FPC cooling capability and also provide supplemental makeup water that may be needed to keep the fuel storage pool full to the rim. The FPC equipment is located in isolated compartments on the second floor of the Reactor Building below the fuel pool facilities. During normal plant operation, area flooding can only occur from rupture of the 300A line which will cause the loss of fuel pool cooling. This is not considered detrimental to safety, since any decrease in the level of the fuel storage pool that may result from water over heating will be made up by the RHR System (Refer to the response to Question 410.34 and 410.37 for the discussions on RHR safety-related make-up capability.)

The FPC pools are structurally designed for Seismic Category I and utilize stainless steel liners to prevent leakage out of the pool. Therefore, leakage from the fuel pool facilities is unlikely and will not impact the operational capability of other equipment.

For the areas identified under items (3) and (4) above, flooding is not possible because there are no water line connections to these rooms.

For item (5) above, the steamline tunnel area is isolated from other areas on this floor through sealed doors and firewalls. Any flooding in this area will be contained and will not propagate into other divisional areas.

3.4.1.1.2.1.6 Evaluation of Floor 600 (3F)

Flooding events at this floor level may involve fuel oil as well as water. Those divisional rooms associated with the emergency diesel generator fuel tank have the potential of leakage from the fuel storage tanks. These rooms must accommodate leakage of 11.4 m^3 for each division. Sunken volumes in the day tank rooms will successfully contain all the volume in the tanks. Leakage from these tanks will also be monitored through safety grade level indication and alarm equipment so that protracted leakage as well as gross leakage can be identified. The rooms are protected by a foam sprinkler system.

Water flooding from the cooling system may occur at about 0.15 m^3/min. If undetected for several hours water may begin cascading down the nearest stairwell but is prevented from damaging safety-related equipment by raising water sensitive equipment at least 200 mm above the floor.

In the SGTS areas, the room cooling equipment may cause flooding at a rate 0.15 m^3/min. Flooding may also occur from manual firefighting in equipment maintenance areas. Large floor areas permit spread of water at limited depth.

Flooding from the standby liquid control tanks is also possible. Maximum tank leak rate will be 0.1 m^3/min so that a response to tank level alarms within 10 minutes will limit the loss. The tanks are inside a diked area with 500 mm side walls which will contain the spill.

3.4.1.1.2.1.7 Evaluation of Floor 700 (M4F)

Flooding in the FMCRD panel rooms may occur from firefighting activities at an input rate of 0.57 m^3/min. Since these activities are manually controlled, any excessive depth of water will be noted and action taken to mitigate water intrusion to other areas.

Flooding on this level may also occur from room cooling systems or from firefighting efforts. Cooling system failures in air supply, exhaust or filter rooms may allow flooding at the rate of 0.3 m^3/min, which will flow out into adjacent corridor areas. If undetected for 10 minutes, the approximate 3 m^3 released may create a depth of a few centimeters over the available floor area; a very limited amount of water will cascade down the stairwells. Safety-related equipment will be raised at least 200 mm off the floor to minimize the impact of flooding.

Firefighting activities in this area would cause water inflow of 0.57 m^3/min under controlled conditions and expected water intrusion is no more than that above.

3.4.1.1.2.1.8 Evaluation of Floor 800 (4F)

Flooding on this floor can be caused by rupture of the RCW surge tanks A, B & C piping. However, each tank and its associated piping is located in a separate compartment which can be sealed off in the event of accidental flooding. Also, the use of pedestals for equipment installation of the RIP supply and exhaust fans and for the DG-C exhaust fans will guard against flooding this equipment.

Flooding in the main reactor hall may occur from reactor service operations. Firefighting water expended into this area would occur at a maximum rate of 0.57 m^3/min but will spread over the large service area available. Minor amounts of water may find the way to stairwells, but would not impede operations.

3.4.1.1.2.1.9 Flooding Summary Evaluation

Floor-by-floor analysis of potential pipe failure generated flooding events in the Reactor Building shows the following:

(1) Where extensive flooding occurs, such as due to suppression pool suction line failure in a basement compartment, propagation to other divisions is prevented by watertight doors. Flooding in one division is limited to that division and flood water cannot propagate to other divisions.

(2) Leakage of water from large circulating water lines, such as RCW lines, may flood rooms and corridors, but through sump alarms and leakage detection systems the control room is alerted and can control flooding by system isolation. Only a limited amount of water accumulation is expected; therefore, safety-related equipment will be kept at least 200 mm off the floor for their protection.

(3) Limited flooding that may occur from manual firefighting or from lines and tanks having limited inventory will cause only a limited amount of water accumulation; therefore, safety-related equipment will be kept at least 200 mm off the floor for their protection.

Therefore, within the Reactor Building, internal flooding events as postulated will not prevent the safe shutdown of the reactor.

3.4.1.1.2.2 Evaluation of Control Building Flooding Events

The Control Building is a seven-story building, which houses (in separate areas) the control room proper, control and instrument cabinets with power supplies, closed cooling water pumps and heat exchangers, mechanical equipment (HVAC and chillers) necessary for building occupation and environmental control for computer and control equipment, and the steam tunnel. The internal flooding events as postulated below involve flooding limited to one division only and will not prevent safe shutdown of the reactor.

The only high energy lines in the Control Building are the main steamlines and feedwater lines which pass through the steam tunnel connecting the Reactor Building to the Turbine Building. There are no openings into the Control Building from the steam tunnel. The tunnel is sealed at the Reactor Building end and open at the Turbine Building end. It consists of reinforced concrete with 1.6m thick walls, floor and ceiling. Any break in a mainsteam or a feedwater line will flood the steam tunnel with steam. The rate of blowdown will cause most of the steam to vent out of the tunnel into the Turbine Building. Water or steam cannot enter the Control Building. All water will flow into the reactor or turbine portions of the steam tunnel. See Subsection 3.6.1.3.2.3 for a description of the subcompartment pressurization analysis performed for the steam tunnel.

Moderate energy water services in the Control Building comprise 700A service water lines, 450A cooling water lines, 150 A cooling water lines to the chiller condenser, 150A fire protection lines, and 150A chilled water heater lines. Smaller lines supply drinking water, sanitary water and makeup for the chilled water system. All rooms are supplied with floor drains to route leakage to the basement floor so that control or computer equipment is not subjected to water.

Maximum flooding may occur from leakage in a 700A service water line at a maximum rate of 12.0 m^3/min. Alarms (two-out-of-four logic) have been installed inside the RCW/RSW heat exchanger room to warn operators of a flood. The first alarm is 400 mm above the basemat. It will warn the operators of flooding in a division. In the case of a RSW piping failure, a second set of alarms (two-out-of-four logic) are located 1500 mm above basemat. This alarm will only sound in the event of a RSW piping failure inside the Control Building. The level sensors are diverse and are powered from their respective divisional Class 1E power supply. These sensors send signals to the corresponding divisions of the RSW systems indicating flooding in that division of the C/B. This signal automatically closes isolation valves, stops the pumps, and alarms the operators in the MCR. The expected release of a service water leak is limited to line volume plus 1500 mm depth of water in a division. Water will be contained inside a division at the bottom level of the control building. A maximum of 5.0m of water is expected assuming 2 km of service water piping out to UHS pump house. Watertight doors will confine the water to a single division.

The failure of a cooling water line in the mechanical rooms of the Control Building may result in a leak of 0.6 m^3/min. Early detection by control room personnel will limit the extent of flooding. Total release from the chilled water system will be limited to line inventory and surge tank volume, spillage of more than 6 m^3 is unlikely. Elevation differences and separation of the mechanical functions from the remainder of the Control Building prevent propagation of the water to the control area.

Flooding events that may result from the failure of the fire fighting systems within the Control Building are directed to the basement by the floor drain system. Manual fire fighting in the Control Building with 2 hand held hoses at 0.57m^3/min each (1.14 m^3/min total) ultimately results in the accumulation of water in the basement. The accumulation of water from 1 hour of fire suppression will not affect water sensitive safety-related equipment in the basement which are located at least 400 mm above the floor. Even in the unlikely event that fire suppression activities extend beyond 1 hour there is a substantial period of time before 1 hour before safety-related equipment may be effected. Furthermore, the Division "A" RSW/RCW heat exchanger room in the basement is separated by water tight barriers from the fire water accumulation in the other two divisions and would remain free of water damage and enable the reactor to be shutdown safely.

On all floors, except the basement, water sensitive equipment, outside the control room, will be raised at least 200 mm off the floor to protect them in case of water intrusion due to manual firefighting or other flooding event on their floor. On the basemat the water sensitive components of the RCW pumps will be kept at least 400 mm off the floor for their protection.

The control room area utilizes a raised floor throughout the complex. The outside wall of the control room complex is sealed to prevent water in the corridor from entering the control room subfloor area. Water sources inside the control room are limited to drinking supplies and bathroom facilities. Drains located in the subfloor area will conduct water to the basement. Water seals in the drain lines will ensure the HVAC boundaries are maintained. Fire fighting activities can be accommodated by the large surface area and the floor drains.

There are no sprinkler systems in the Control Building. Hose and standpipes are located in the corridors. Service equipment rooms may build up limited water levels from either service water, cooling water, or chilled water leaks, but elevation differences prevent intrusion of water into control areas. Control room responses to those various levels of flooding may extend from system isolation and correction to reduction of plant load or shutdown, but control room capability is not compromised by any of the postulated flooding events.

3.4.1.1.2.3 Evaluation of Radwaste Building Flooding Events

The Radwaste Building is a reinforced concrete structure consisting of a substructure 13.7 m below grade at the basemat top and a super-structure 13.7 m above grade. This building does not contain safety-related equipment and is not contiguous with other plant structures except through the radwaste piping and tunnel. In case of a flood, the building substructure serves as a large sump which can collect and hold any leakage within the building. Also, the medium and large radwaste tanks are housed in sealed compartments which are designed to contain any spillage or leakage from tanks that may rupture. The piping that transfer the liquid waste from the other buildings to the Radwaste Building traverse through a tunnel. The top of the radwaste tunnel is at grade (Figure 1.2-23e). Seals are provided for all penetrations from the tunnel to prevent building to building flooding.

The structural design of this building is such that no internal flooding is expected or will occur under the worst case conditions from medium and large radwaste tanks.

Therefore, it can be concluded from the above analysis that there is no uncontrolled path of radioactive liquid from the Radwaste Building under the conditions of worst-case internal flooding.

3.4.1.1.2.4 Evaluation of Service Building Flooding Events

The Service Building is a non-seismic concrete structure consisting of four floors, two above and two below grade. It serves as the main security entrance to the plant and provides the controlled access corridors to the Control Building, the Turbine Building, and the Reactor Building. This building does not house any safety-related equipment.

Some of the connecting corridors to other buildings are below plant grade as indicated in Table 3.4-1. These passage ways are water tight to prevent seepage into the corridors. Also, the controlled access corridors employ watertight doors to guard against water leakage from the Service Building into structures that house safety-related equipment.

The only plant piping that runs through this building are those needed for fire protection, water services, HVAC heaters and chillers, and for draining the sumps. This building has floor drains and two sump pumps (HCW & HSD) for collecting and transferring the liquid waste. Under worst-case conditions, flooding from line ruptures is unlikely and can be contained from spreading to the structures that house safety- related equipment.

3.4.1.1.2.5 Evaluation of Turbine Building Flooding Events

Circulating Water System and Turbine Building Service Water (TSW) System are the only systems large enough to fill the Turbine Building; therefore, only these two systems can flood into adjacent buildings.

A failure of the Circulating Water System will result in the total flooding of the Turbine Building below grade. Another failure in TSW System will result in the total flooding of Turbine Building still within the TSW System equipment room. These are accomplished by leak detectors in a condenser pit and TSW System equipment room, and automatic means to shutdown those systems. Water is prevented from crossing to other buildings by two means in the case of the leak detection failure. The first is a normally closed alarmed door in the connecting passage between the Turbine Building and Service Building. The second is that the radwaste tunnel will be sealed at both ends to prevent water from either entering the tunnel or leaving the tunnel. A large hydrostatic head is prevented by a large non-water-tight truck door at grade to provide a release point for any flooding water.

Because of the large size of the circulating water system and the TSW System, leaks will fill the condenser pit and the TSW System equipment room quickly. Monitors were added in the condenser pit and the TSW System equipment room of the Turbine Building to provide leak detection and an automatic means to shutdown the Circulating Water System and TSW System in the event of flooding in the Turbine Building (Subsections 10.4.5.2.3 and 10.4.5.6).

3.4.1.2 Permanent Dewatering System

There is no permanent dewatering system provided for in the flood design.

3.4.2 Analytical and Test Procedures

Since the deign flood elevation is 30.5 cm below the finished plant grade, there is no dynamic force due to flood. The lateral hydrostatic pressure on the structures due to the design flood water level, as well as ground and soil pressures, are calculated.

Structures, systems, and components in the ABWR Standard Plant are designed and analyzed for the maximum hydrostatic and hydrodynamic forces in accordance with loads and load combinations indicated in Subsections 3.8.4.3 and 3.8.5.3 using well established methods based on the general principles of engineering mechanics. All Seismic Category I structures are in stable condition due to either moment or uplift forces which result from the proper load combinations including the design basis flood.

3.4.3 COL License Information

3.4.3.1 Flood Elevation

The COL applicant will ensure the design basis flood elevation for the ABWR Standard Plant structures will be 30.5 cm below grade (Section 3.4).

3.4.3.2 Ground Water Elevation

The COL applicant will ensure the design basis ground water elevation for the ABWR Standard Plant structures will be 61.0 cm below grade (Section 3.4).

3.4.3.3 Flood Protection Requirements for Other Structures

The COL applicant will demonstrate, for the structures outside the scope of the ABWR Standard Plant, that they meet the requirements of GDC 2 and the guidance of RG 1.102 (Subsection 3.4).

3.4.4 References

3.4-1 Crane Co., "Flow of Fluids Through Valves, Fittings, and Pipe," Technical Paper No. 410, 1973.

3.4-2 ANSI/ANS 56.11, Standard, "Design Criteria for Protection Against the Effects of Compartment Flooding in Light Water Reactor Plants."

3.4-3 Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants."

Table 3.4-1 Structures, Penetrations, and Access Openings Designed for Flood Protection

Structure	Reactor Building	Service Building	Control Building	Radwaste Building	Turbine Building
Design Flood Level (mm)	11,695	11,695	11,695	11,695	11,695
Design Ground Water Level (mm)	11,390	11,390	11,390	11,390	11,390
Reference Plant Grade (mm)	12,000	12,000	12,000	12,000	12,000
Base Slab (mm)	–8,200	–2150 & 3500	–8,200	–1,500	5,300
Actual Plant Grade (mm)	12,000	12,000	12,000	12,000	12,000
Building Height (mm)	49,700	22,200	22,200	28,000	54,300
Penetrations Below Design Flood Level (Notes 1 through 4)	Refer to Table 6.2-9	None	RCW, RSW and miscellaneous lines, and electrical penetrations	None, except radwaste piping	Radwaste piping
Access Openings Below Design Flood Level (Notes 5 and 6)	Access way from S/B @ 4,800 mm	Area access way from R/B @ 3500 mm,	(Fig. 1.2-18)		
		Area access ways from C/B @ –2150mm, 3500mm, and 7900mm,	Hx area access from S/B @ –2150 mm, (Fig. 1.2-15) Area access from S/B @ 3500 mm, (Fig. 1.2-18) Area access from S/B @ 7900 mm (Fig. 1.2-15)		
		Area access way from T/B @ 3500mm	(Fig. 1.2-24)		Area access from S/B @ 5,300 mm

Notes:

(1) Watertight penetrations will be provided for all Reactor, Control, Turbine and Radwaste Building penetrations that are below grade.

(2) The safety-related and non-safety-related tunnels prevent the lines running through them from being exposed to outside ground flooding.

(3) Penetrations below design flood level will be sealed against any hydrostatic head resulting from the design basis flood, or from a moderate energy pipe failure in the tunnel or inside a connecting building.

(4) Waterproof sealant applied to the building exterior walls below flood level will also be extended a minimum of 150 mm along the penetration surfaces.

(5) Watertight doors (bulkhead type) are provided at all Reactor and Control Building access ways that are below grade.

(6) The figure shown best depicts the indicated accesses.