Attachment 1

Millstone Unit 2
Spent Fuel Pool Boron Dilution Analysis
Summary for a NUHOMS 32PT DSC

Attachment 1 Table of Contents

1.0 Introduction

The purpose of this evaluation is to ensure that sufficient time is available to detect and terminate a boron dilution event in the Millstone Unit 2 Spent Fuel Pool to maintain sub-criticality in the fuel contained inside a NUHOMS 32PT DSC.

Current Situation
Millstone 2 (MP2) currently credits 600 ppm of soluble boron in the MP2 SFP to maintain k_{eff} of the *fuel in the storage racks* of the SFP to less than or equal to 0.95 on a 95/95 basis. The MP2 Operating License TS currently require a minimum of 1720 ppm of soluble boron when fuel is stored in the SFP. This value of 1720 ppm soluble boron concentration ensures that should a boron dilution event occur, sufficient time is available to detect and terminate the boron dilution event prior to reaching 600 ppm of boron, thus ensuring that the fuel in the storage racks of the SFP would have a k_{eff} of less than or equal to 0.95. This analysis was previously reviewed and approved by the NRC (Ref: 7.15). The boron dilution analysis presented in this evaluation does not alter this existing boron dilution analysis for the fuel in the storage racks.

Proposed Situation
Millstone 2 is proposing to load fuel in a NUHOMS 32PT Dry Storage Canister (DSC) because the MP2 SFP is nearly full. The DSC would be located in the Cask Laydown Pit of the SFP. The Technical Specifications associated with the NUHOMS 32PT Dry Storage Canister (DSC) require a certain soluble boron concentration for loading and unloading of fuel within the DSC to ensure that k_{eff} of the fuel in the DSC is maintained below 0.95. This DSC TS boron concentration is extremely conservative since it does not credit fuel burnup. This Technical Evaluation demonstrates that if a boron dilution event where to occur in the Millstone 2 SFP, that the boron dilution event could be detected and terminated before criticality is reached by the fuel in the NUHOMS 32PT DSC. The boron dilution analysis presented here for the *fuel in the DSC*, does not alter the previous boron dilution analysis that was for the *fuel in the storage racks*.

This Technical Evaluation (TE) includes the following plant specific features and potential events:
- instrumentation
- administrative procedures
- boration sources
- dilution sources
- dilution flow rates
- boron dilution initiating events
- boron dilution times and volumes

2.0 SPENT FUEL POOL AND RELATED SYSTEM FEATURES

This Section provides background information on the SFP and related systems.

2.1 Spent Fuel Pool

The SFP is located in the auxiliary building. The pool is designed for the underwater storage of spent fuel assemblies after removal from the reactor core. The spent fuel storage racks, located in the bottom of the SFP are licensed to accommodate fuel assemblies in both intact and consolidated forms. The SFP is designed to maintain approximately 24 feet of borated water above the stored fuel assemblies (Ref.: 7.5.5). Connected to the spent fuel pool are the transfer canal and the cask laydown pit. The transfer canal and cask laydown pit are normally open to the pool, but may be isolated from the spent fuel pool by use of bulkhead gates. The cask laydown pit is the area where a fuel transfer cask is placed.

2.2 Spent Fuel Pool Storage Racks and Pool Volume

There are 3 Regions for fuel storage, designated Regions A, B and C. The stainless steel storage racks consisting of vertical cells grouped in parallel rows, are designed for a center-to-center distance of 9.8 inches in Regions A and B and 9.0 inches in Region C. Spent fuel decay heat is removed by the SFP cooling system described below. The arrangement also provides for adequate convective cooling of stored fuel assemblies.

The fuel storage racks are designed to maintain a K_{eff} of 0.95 or less during normal conditions and under abnormal conditions. Borated spent fuel pool water at a concentration of 600 ppm is credited to maintain a K_{eff} of 0.95 or less under normal conditions. The Operating License Technical Specifications require 1720 ppm of soluble boron in the spent fuel pool with fuel in the pool (Ref: 7.4.2 and 7.4.5). A boron dilution analysis was submitted to and approved by the NRC (reference 7.8 and 7.15) that demonstrated there is sufficient time to detect and mitigate a potential boron dilution event from reaching 600 ppm, starting from an initial spent fuel pool soluble boron concentration of 1720 ppm.

The volume of water in the SFP with the SFP at the low level setpoint, is 29,318 ft^3 or 219,314 gallons (Ref.: 7.1.1) of water. This value of 219,314 gallons has been adjusted to remove the fuel storage rack volume and fuel volume. The fuel storage racks displace approximately 600 ft^3, and the fuel assembly volume displaced is 5,384 ft^3 (Ref.: 7.1.1) assuming fuel in all storage locations.

The transfer canal is connected to the spent fuel pool, and is normally open to the spent fuel pool. The transfer canal has a capacity of 76,387 gallons (Ref.: 7.2.5) and the gate area has a capacity of 1,615 gallons (Ref: 7.2.5). No credit is taken here for the volume of water in the cask laydown pit, which is also normally connected to the SFP.

Thus the minimum total water volume of the spent fuel pool and transfer canal with the spent fuel pool water level at the low level setpoint is: 219,314 + 76,387 + 1,615 = 297,316 gallons, which is conservatively rounded down to 297,000 gallons.

2.3 Spent Fuel Pool Cooling

The function of the SFP cooling system is to remove decay heat generated by spent fuel assemblies stored in the pool by limiting the temperature of the borated pool water to an acceptable level, thereby ensuring the cladding integrity of stored spent fuel assemblies. The SFP cooling system consists of 2 trains of SFP cooling, which can be augmented by the shutdown cooling system during refueling outages. The SFP cooling system and shutdown cooling system are cooled by the Reactor Building Component Cooling Water (RBCCW) System.

2.4 Spent Fuel Pool Instrumentation

The SFP is provided with level and temperature instruments that provide annunciation in the main control room (Ref.: 7.5.6). The high level alarm of the SFP (Ref 7.2.1) will initiate the operators response to a potential boron dilution event in the SFP. The SFP low level alarm is set for a water depth of 38 feet. The setpoint of this alarm will ensure the TS minimum level is maintained (Ref.: 7.4.4). The high level alarm is set for a water depth of 39'-2" (Ref.: 7.2.1). Thus there is about 14 inches between the low level alarm and the high level alarm. The high level alarm is about 16 inches below the SFP operating deck.

If the pool level were to be raised from the low level alarm point to the high level alarm point, a dilution of approximately 11,074 gallons could occur before the alarm is received in the control room. This is calculated by 14 inches between the low and high level alarm setpoint and the value of 791 gallons/inch (Ref 7.2.5) needed to change SFP level, thus:
14 inches * 791 gallons/inch = 11,074 gallons.

If the pool level were to be raised from the high level alarm point to the point of overflowing the SFP at the operating deck, a dilution of approximately 12,656 gallons would be required. This is calculated by 16 inches between the high level alarm setpoint and the overflow level, and the value of 791 gallons/inch (Ref 7.2.5) needed to change SFP level, thus:
16 inches * 791 gallons/inch = 12,656 gallons.

SFP temperature instrumentation provides continuous monitoring (high temperature alarm) and recording of pool water temperatures by main control room personnel. A low-flow alarm will alert operating personnel that one or both SFP cooling water pumps has failed to operate. SFP cooling water flow instrumentation annunciates a low SFP cooling water flow alarm in the main control room. SFP heat exchanger outlet instrumentation annunciates a high-temperature alarm in the main control room.

2.5 Spent Fuel Pool Administrative Procedures

Currently, Operating License Technical Specifications (TS) requires the soluble boron concentration in the SFP to be greater than or equal to 1720 ppm (Ref.: 7.4.2) whenever a fuel assembly or consolidated fuel storage box is stored in the spent fuel pool.

The cask to be used for dry storage at Millstone Unit 2 is the NUHOMS 32PT Dry Storage Canister (DSC). The current Technical Specification requirements for the 32PT DSC are Amendment 7 to CofC 1004 (Ref: 7.13). TS 1.2.15a of Amendment 7 requires 2500 ppm of soluble boron when loading or unloading fuel from the 32PT DSC. There is also a proposed Amendment 9 to CofC 1004 (Ref 7.14). In the proposed Amendment 9, TS 1.2.15a requires from 1800 ppm to 2500 ppm of soluble boron, depending on the fuel enrichment, when loading or unloading fuel from the 32PT DSC. The required 32PT DSC TS surveillance interval for verifying adequate boron concentration is within 4 hours of loading the 1st fuel assembly or within 4 hours of flooding the DSC for fuel removal. Subsequent verification is every 48 hours.

Millstone proposes to add the following 5 requirements to the ISFSI procedures.
***When a 32PT DSC is in the SFP with fuel inside the DSC*:**
(1) The requirement to verify that the transfer canal bulkhead gate is not in place to block the opening to the spent fuel pool.
(2) Visual verification every 3 hours that the spent fuel pool is not overflowing.
(3) Valve 2-RW-350 must remain closed.
(4) Valves 2-PMW-295, 2-PMW-408 and 2-PMW-409 must be placed in the closed position if all personnel leave the SFP operating deck.
(5) Spent Fuel Pool Cooling Flow must be at least 850 gpm.

2.6 Boration Sources

The normal source of borated water to the SFP is from the refueling water storage tank (RWST). The boron concentration in the RWST is maintained above 1720 ppm in accordance with Operating License TS Surveillance Requirement (Ref.: 7.4.1 and 7.4.3).

3.0 SPENT FUEL POOL DILUTION EVENT

3.1 Calculation of Boron Dilution Times and Volumes

3.1.1 Criticality Analysis

Millstone 2 Operating License Technical Specifications require the spent fuel pool boron concentration to be maintained ≥ 1720 ppm of soluble boron, with fuel in the SFP.

During loading of the 32PT DSC in the cask laydown pit of the spent fuel pool, the boron concentration in the SFP and DSC will be required to be maintained greater than or equal to the CofC 1004 Amendment 7 TS 1.2.15a limit of 2500 ppm of soluble boron. The allowable fuel enrichment and Poison Rod Assembly (PRA) requirements corresponding to the 2500 ppm minimum boron concentration are specified in CofC 1004 Amendment 7 TS Table 1-1g. Transnuclear (TN) performed a criticality analysis (reference 7.6) that showed that even if the soluble boron concentration was reduced below 2500 ppm, a soluble boron concentration of 1700 ppm would maintain sub-criticality in the 32PT DSC. A bounding fuel enrichment and PRA combination was used in the analysis. This analysis is extremely conservative in that no credit is taken for fuel burnup. Further, this analysis is highly conservative since optimum moderation is used in the calculations. Boron dilution with full moderation (DSC being fully flooded at all times during the event) is more realistic and results in a reduction in the boron concentration requirement to maintain sub-criticality.

TN performed a second criticality calculation to address pending Amendment 9 to CofC 1004, which modifies TS 1.2.15a to allow a sliding scale of required soluble boron concentration from 1800 ppm to 2500 ppm, depending on fuel enrichment. TN performed a criticality analysis (reference 7.6) that showed that even if the soluble boron concentration was reduced below 1800 ppm, a soluble boron concentration of 1200 ppm would maintain sub-criticality in the 32PT DSC. This analysis is extremely conservative in that no credit is taken for fuel burnup. Further, this analysis is highly conservative since optimum moderation is used in the calculations. Boron dilution with full moderation (DSC being fully flooded at all times during the event) is more realistic and results in a reduction in the boron concentration requirement to maintain sub-criticality.

Thus the criticality analysis performed by Transnuclear covers the range of required boron concentrations of 1800 ppm to 2500 ppm, that are allowed by the existing approved Amendment 7 and the proposed Amendment 9 to CofC1004. This range of boron concentrations from 1800 to 2500 ppm correspondingly covers a range of initial fuel enrichments/PRA's.

Based on the criticality analysis performed by Transnuclear (reference 7.6), for fuel with a required soluble boron concentration of 2500 ppm to meet $k_{eff} \leq 0.95$ on a 95/95 basis, a soluble boron concentration of 1700 ppm will maintain the $k_{eff} < 1.00$ with a 95% probability at a 95% confidence level.

Based on the criticality analysis performed by Transnuclear (reference 7.6), for fuel with a required soluble boron concentration of 1800 ppm to meet $k_{eff} \leq 0.95$ on a 95/95 basis, a soluble boron concentration of 1200 ppm will maintain the $k_{eff} < 1.00$ with a 95% probability at a 95% confidence level.

As will be shown later in this evaluation, the boron dilution event starting from 2500 ppm produces the shortest dilution time interval that requires the operators to detect and terminate the dilution event.

3.1.2 Boration Dilution Times and Volumes

The dilution times and volumes calculated here are based on a starting SFP soluble boron concentration of 2500 ppm and maintaining a final concentration of 1700 ppm of soluble boron in the SFP. It will be shown that this initial condition for fuel requiring 2500 ppm of SFP soluble boron results in the shortest (conservative) possible dilution times.

There is no automatic SFP level control system in the SFP, so that any dilution to the SFP will add water to the SFP. Therefore, the addition of unborated water to the SFP will lead to increased SFP water level, and if not controlled, an overflow of the SFP. The method used to analyze this situation will be the continuous dilution method (feed and bleed). The continuous dilution method assumes unborated water is added at a constant rate with a constant rate of removal. This physically corresponds to unborated water being added to the SFP, and borated water at the current concentration being lost by overflow of the SFP. This feed and bleed method will give conservative results even if the dilution is initially a batch dilution as SFP level is raised. For conservative results, it is also assumed that the initial SFP water volume will be at the low alarm level, exclude the cask laydown pit and also exclude the water volume displaced by the fuel and fuel racks.

Excluding the cask laydown pit and by conservatively only crediting the SFP water level is at the SFP level low alarm setpoint, the calculated SFP volume is 297,000 gallons, as stated earlier in Section 2.2.

A continuous "feed and bleed" dilution of the SFP will yield the most conservative results in this boron dilution analysis. This will be calculated by the equation for change in boron mass per unit of time.

$$dm/dt = m_{in}^{o} - m_{out}^{o} \text{ (Ref: 7.1.1)}$$

where m_{in}^{o} , m_{out}^{o} are the mass flow rates of boron in and out, respectively.

Ignoring the minimal temperature effects, the mass flow rate of boron in each instance is equal to the product of the volumetric flow rate of diluted water, Q, and the concentration of boron, C, within the diluted water.

$$m^{o} = Q * C \text{ (Ref: 7.1.1)}$$

If the concentration of water volume added is zero and the flow rate out is equal to the flow rate in, the equation can be rewritten as:

$$dm/dt = -Q_{out} * C_{out} = V_{SFP\ Total} * dC/dt \text{ (Ref: 7.1.1)}$$

where:

$V_{SFP\ Total}$ = volume of the SFP, at the low level alarm
dC/dt = change in concentration of the SFP with respect to time

Therefore, if the equation above is rearranged and integrated from zero to time (t), the following would be the result:

$$-Q_{out} * t = V_{SFP\ Total} * (\ln C_t - \ln C_o) \text{ (Ref: 7.1.1)}$$

Realizing that Q is equal to the volume divided by time and that the volume out is equal to the volume in, the left side of the equation reduces to the negative of the volume in V_{in} . Then, by moving the negative on the left to the right and realizing that C_t is equal to our final concentration and C_o is our initial concentration, the above equation can be rewritten in its final form.

$$V_{in} = V_{SFP\ Total} * \ln (C_t / C_o) \text{ (Ref: 7.1.1)}$$

The SFP volume at the low level alarm, less the volume displaced by the racks and fuel, is 297,000 gallons. Using this volume, we can determine the total dilution volume needed to dilute the SFP from the initial 2500 ppm boron concentration to 1700 ppm, by solving the above equation for V_{in}.

Inserting the following values:
$V_{SFP\ Total}$ = 297,000 gallons
C_t = 2500 ppm
C_o = 1700 ppm

V_{in} = 297,000 gals * ln (2500 ppm / 1700 ppm)
V_{in} = 114,541 gallons

The result is 114,000 gallons, conservatively rounding down. Therefore, any dilution source not capable of supplying 114,000 gallons of unborated water will not be capable of diluting the pool to 1700 ppm from a starting value of 2500 ppm.

As discussed in Section 3.1.1, the Transnuclear (TN) criticality analysis (Ref 7.6) also performed calculations for the NUHOMS 32PT DSC for fuel with a starting soluble boron concentration requirement of 1800 ppm. TN performed a criticality analysis that showed that even if the soluble boron concentration was reduced below 1800 ppm, a soluble boron concentration of 1200 ppm would maintain sub-criticality in the 32PT DSC. For a dilution from 1800 to 1200 ppm, the following volume of water would be required.

Inserting the following values:
$V_{SFP\ Total}$ = 297,000 gallons
C_t = 1800 ppm
C_o = 1200 ppm

$$V_{in} = 297{,}000 \text{ gals} * \ln(1800 \text{ ppm} / 1200 \text{ ppm})$$
$$V_{in} = 120{,}423 \text{ gallons}$$

Thus the volume for a dilution from 1800 to 1200 ppm is more than the volume of water required for a dilution from 2500 to 1700 ppm. Therefore, the dilution from 2500 ppm to 1700 ppm is more restrictive (gives shorter dilution times) and will be analyzed as the limiting case.

For dilution sources with automatic make-up, the capacity for dilution is essentially infinite. Should one of these sources begin adding unborated water to the pool, the pool level would rise to the high level alarm setpoint, alerting the control room operators. Should the high level alarm fail, and no operator actions were taken, the pool will eventually fill to the curb and begin overflowing.

As stated earlier in Section 2.4, the volume of water from the SFP low level setpoint to high level setpoint is approximately 11,074 gallons, with an additional approximately 12,656 gallons from the high level setpoint to pool overflow. Thus a total of approximately 23, 730 gallons of water must be added to the SFP to overflow the SFP. Later in this evaluation, it is shown that a 200 gallon per minute (gpm) dilution flow is the limiting dilution flowrate. At a 200 gpm dilution flow rate into the spent fuel pool, the pool will overflow in 2 hours if level was initially at the low level setpoint. This is calculated by: 23, 730 gallons/ 200 gpm = 118.65 minutes, which is about 2 hours.

ISFSI administrative procedures will require that if a DSC is in the SFP with fuel inside the DSC, every 3 hours it will be visually verified that the SFP is not overflowing. As will be justified later in this Technical Evaluation, for a bounding dilution flow rate of 200 gpm of unborated water, 9.5 hours are needed for the SFP soluble boron concentration to change from 2500 ppm to 1700 ppm. This is simply calculated as follows, using the 114,000 gallons of water previously determined as the volume needed to dilute the pool from 2500 to 1700 ppm, and the worst case dilution flowrate of 200 gpm:

114,000 gallons / 200 gpm = 570 minutes = 9.5 hours

Thus at 200 gpm of dilution flow into the SFP, it will take 9.5 hours to dilute the SFP from 2500 ppm to 1700 ppm. Since it will take about 2 hours to overflow the pool, and (when a DSC is in the SFP with fuel in the DSC) every 3 hours a visual check is made to verify the pool is not overflowing, a maximum of 5 hours will occur before detection of the dilution event. This allows 4.5 hours to terminate the dilution event, which is a more than adequate time interval to terminate the event. This is a extremely conservative time estimate since:

- The spent fuel pool high level alarm should have alerted the operators of an unusual situation, and the alarm response procedure for this alarm contains the guidance for a dilution event.
- Personnel should be present in the spent fuel pool area since a DSC is being loaded/unloaded, and they would observe the dilution event in progress.

In summary, the ability to prevent the SFP soluble boron concentration from being diluted from the 32PT DSC TS minimum value of 2500 ppm to a value of 1700 ppm will meet one of the following two criteria:

- Any dilution source not capable of supplying 114,000 gallons of unborated water will not be capable of diluting the pool to 1700 ppm from a starting value of 2500 ppm.

- If the dilution flowrate of unborated water is $\leq$ 200 gpm, then at least 9.5 hours will be needed for the SFP soluble boron concentration to be reduced from 2500 ppm to 1700 ppm. All dilution scenarios evaluated here will eventually cause a SFP high water level alarm in the control room, and as a back-up, administrative procedures will require every 3 hours a visual check is made to verify the pool is not overflowing, whenever a DSC is in the SFP with fuel in the DSC.

3.1.3 Mixing During the Dilution Event

As discussed above, the feed and bleed analysis of the dilution event to the spent fuel pool assumes instantaneous perfect mixing. The instantaneous perfect mixing assumption is conservative for the reasons discussed next.

The Millstone 2 spent fuel pool consists of the spent fuel pool volume with 2 adjacent connected volumes, called the transfer canal and the cask laydown pit. The transfer canal is connected to the spent fuel pool through a gate opening on the West side of the spent fuel pool. The cask laydown pit is connected to the spent fuel pool through a gate opening on the East side of the spent fuel pool. The DSC will be located in the bottom of the cask laydown pit.

Postulated dilutions of the spent fuel pool will take place into the spent fuel pool or the transfer canal. For reasons described in the next section of this evaluation, dilutions directly entering the cask laydown area are not expected to occur, or if they do, they will be very limited in volume and not limiting.

The addition of unborated water to the spent fuel pool must enter through either one of two basic pathways. The first pathway is for water to spill into the top of the spent fuel pool (or the transfer canal connected to the spent fuel pool) through a leak occurring from several possible sources discussed later in this evaluation. The second pathway is for unborated water to enter the spent fuel pool through the spent fuel pool cooling return pipes. There are 3 spent fuel pool cooling return pipes to the spent fuel pool. Two of the three spent fuel pool cooling return pipes are in the spent fuel pool, far away from the cask laydown pit which could contain a DSC. The third spent fuel pool cooling return pipe is in the cask laydown pit, and can be isolated by valve 2-RW-350. As described in the next section, valve 2-RW-350 (normally closed) will be closed to ensure that no spent fuel pool cooling flow goes to the cask laydown pit, thus precluding a direct dilution to the cask laydown pit through this line.

Addressing each of the 2 possible dilution pathways.

Concerning the first dilution pathway, if unborated water spills into the top of the spent fuel pool, the pool will overflow and most of the overflow water will be the unborated water. If most of the water spilling over the top of the spent fuel pool is unborated water, the feed and bleed assumption will be conservative. Further, the unborated water being added to the pool is very far away from the DSC. The water being added is at the top of the spent fuel pool and the DSC is in the bottom of the cask laydown pit. The cask laydown pit boron concentration will lag behind the spent fuel pool concentration since the cask laydown pit is connected to the spent fuel pool through the limited area of the gate opening, which will slow down mixing. There is no forced circulation between the spent fuel pool and cask laydown pit. Thus the feed and bleed assumption will be conservative since the dilution water being added is far away from the DSC and the cask laydown pit boron concentration will lag the spent fuel pool concentration due to the gate opening, and the lack of forced flow between the SFP and cask pit.

Concerning the second dilution pathway, if unborated water enters the spent fuel pool through spent fuel pool cooling, the pool will eventually overflow. The unborated water being added to the pool is very far away from the DSC. The water being added is at the bottom of the spent fuel pool and the DSC is in the bottom of the cask laydown pit. The cask laydown pit boron concentration will lag behind the spent fuel pool concentration since the cask laydown pit is connected to the spent fuel pool through the limited area of the gate opening, and there is no forced flow between the cask pit and SFP, which will slow down mixing. Thus the feed and bleed assumption will be conservative since the dilution water being added is far away from the DSC, and the cask laydown pit boron concentration will lag the spent fuel pool concentration due to the gate opening.

The other item to be considered is the amount of mixing that will occur in the spent fuel pool during the dilution. Procedures will require at least 850 gpm of SFP cooling flow during the time period when a DSC with fuel is in the cask laydown pit. This corresponds to 51000 gallons per hour (850 gpm x 60 minutes). As previously discussed, the volume of the spent fuel pool is 297,000 gallons, thus at 850 gpm, the spent fuel pool volume is being turned over every 5.8 hours (297000/51000). As discussed later in this evaluation, the dilution to reach critical will take 9.5 hours, so that spent fuel pool volume is being turned over about 1.5 times during the dilution. This is adequate to promote mixing during the dilution.

In summary, instantaneous mixing assumption associated with the use of a feed and bleed dilution is conservative for 3 reasons: (1) the location of the unborated water entering the spent fuel pool is far away from the DSC, which is located in the bottom of the cask laydown pit. (2) the cask laydown pit boron concentration will lag behind the spent fuel pool boron concentration due to the limited area of the gate opening connection between the spent fuel pool and cask laydown pit, and (3) A minimum of 850 gpm of SFP cooling flow will promote mixing of the dilution water.

3.1.4 Direct Dilution into the Cask Laydown Pit

Dilution of the cask pit thru the SFP cooling return line

A direct dilution into the cask laydown pit must be avoided. The DSC will be located in the bottom of the cask laydown pit, and the cask laydown pit is connected to the SFP through a gate opening, with no forced circulation between the SFP and the cask pit. This gate opening limits the mixing and is conservative if the dilution occurs into the spent fuel pool, but if the dilution were to occur directly into the cask laydown pit, the boron concentration would drop much faster than described in section 3.1.2. Therefore it is important that dilutions to the cask laydown pit be avoided. ISFSI procedures will allow a small amount of unborated water to be added to the spent fuel pool or cask laydown pit during cask handling operations. The possibility of significant dilution directly to the cask laydown pit will be avoided as follows:

Spent Fuel Pool Cooling has a outlet pipe that goes directly to the cask laydown pit, through valve 2-RW-350. Valve 2-RW-350 (normally closed) must be closed to ensure that no spent fuel pool cooling flow goes to the cask laydown pit. This will prevent a direct dilution to the cask laydown pit through this line. This precludes addition of unborated water entering the SFP through the SFP cooling return line due to an inadvertent opening of the PMW fill line (section 4.3), inadvertent opening of the auxiliary feed makeup line (section 4.2) or a tube break in the spent fuel pool cooling heat exchanger (section 4.4).

Dilution of the cask pit by water spilling into the cask pit at the SFP operating deck

The other potential path for direct dilution of the cask laydown pit is for water leakage into the cask pit spilling into the cask pit from the operating deck, due to a leak of water from another system. A walkdown of the spent fuel pool operating deck shows that there is only 1 credible source of water that could dilute the cask pit directly by water spilling into the cask pit from the spent fuel pool operating deck. This potential dilution source is the PMW hose station (section 5.2) located near the cask laydown pit. All other potential leakage sources (sections 5.3 through 5.7) are eliminated as not being credible sources of direct dilution to the cask pit as explained next.

Dilution of the cask pit from dilution sources described in sections 5.3 through 5.7

The potential sources of dilution described in sections 5.3 through 5.7 are not credible sources of dilution directly spilling into the cask laydown pit since these potential dilution sources are far away from the cask laydown pit and would leak into the spent fuel pool or transfer canal, since the SFP or transfer canal are between the potential leak source locations and the cask laydown pit. The one exception to this is the North roof drain pipe described in section 5.7, which is addressed separately next.

Dilution of the cask pit from the North Roof Drainpipe

The overhead roof drainpipe on the north side of the spent fuel pool is a seismically supported drain line, as described in section 5.7. This overhead roof drain does not go directly over the cask pit, but if it were to leak vertically, it would leak only a few feet north of the cask pit. Since it is a roof drain, the water draining inside the pipe is not under pressure, which will limit the leak rate and the area that leaking water would spray laterally. Because of the physical layout surrounding the cask laydown pit, it is very unlikely that leaking water from the roof drain would enter the cask pit, but rather would enter the spent fuel pool or the floor drain system. This is because the spent fuel pool has a rail well on the north side of the pool that has its own drain. Further, the cask pit has additional protection on the north side due to a surface mounted rail, which will direct leaking water north of the rail, into the rail well or into the spent fuel pool. Further, the simultaneous events that would have to take place for any leakage to enter the cask pit is not credible. For the failure of the roof drain to allow water to enter the cask pit, the following must occur at the same time: (1) A DSC with fuel must be in the cask pit, (2) it must be raining, (3) the crack of the pipe must occur <u>at the time</u> the DSC is in the cask pit and it is raining, and (4) no personnel are present on the SFP floor to see the leak, otherwise mitigation measures could be taken, and (5) the leaking water must find its way to the cask laydown pit, even though the barriers described above should prevent water from entering the cask pit.

It is important to emphasize that the leak in the roof drain pipe would have to occur at the time the DSC was in the cask pit, since, if the leak in the pipe had occurred earlier, the leakage from the pipe would have been noticed the last time it rained, by operators during routine shift rounds. The simultaneous events described above are not credible, and therefore this dilution path is not credible.

<u>Dilution of the cask pit from the PMW hose station near the cask pit</u>

As described in section 5.2, there is a PMW hose station located near the cask pit. This is a credible source of dilution to the cask pit. As stated in section 5.2, this system is designed to seismic Class 2 requirements. This hose station terminates in 2 available pipe connections. One of the 2 connections commonly has a hose attached for use in SFP activities. Each pipe connection has its own isolation valve, 2-PMW-408 and 2-PMW-409. Upstream of these 2 valves is a common isolation valve, 2-PMW-295. There is a short run of pipe upstream of the isolation valve 2-PMW-295 that runs to, and then through the north wall of the SFP. Should any type of a PMW leak or inadvertent discharge of PMW occur from this hose station, and with personnel present in the area, the appropriate isolation valve can be used to terminate the leak or inadvertent discharge. Should a pipe leak occur in the short section of pipe upstream of isolation valve 2-PMW-295, the PMW pump(s) can be turned off, which would terminate the discharge.

A concern with this hose station is if there is a DSC with fuel in the cask pit, and the area is left unattended. If a leak were to occur for whatever reason from the PMW hose station, the possibility exists that this water could reach the cask laydown pit. For the portion of the hose station downstream of valve 2-PMW-295, this concern can be eliminated by requiring that all 3 valves, 2-PMW-295, 2-PMW-408 and 2-PMW-409, be placed in the closed position, if the DSC (with fuel) is to be left unattended in the cask pit. By closing these 3 valves, double isolation is available for any leakage out the 2 pipe connections. By closing 2-PMW-295, isolation of any potential pipe leak downstream of 2-PMW-295 is provided.

The last concern with this hose station, is for the potential of a pipe leak in the PMW pipe that runs through the north wall of the SFP to valve 2-PMW-295. This short run of pipe to the hose station normally has no flow. Therefore it is unlikely for a leak in this pipe. To quantify the potential leak size from this pipe, calculations were performed (reference 7.1.1) specific to this pipe. The leak methodology used is consistent with that described in section 5.1. Per reference 7.1.1, a leak in this section of PMW pipe would be < 7 gpm. If such a leak were to occur, it is unlikely that much, if any of this leakage would make it to the cask laydown pit, because of the physical layout surrounding the cask laydown pit. Such leakage would enter the spent fuel pool or the floor drain system. This is because the spent fuel pool has a rail well on the north side of the pool that has its own drain. Further, the cask pit has additional protection on the north side due to a surface mounted rail, which will direct leaking water north of the rail, into the rail well or into the spent fuel pool. However, for conservatism, it will be calculated next if all 7 gpm of the PMW leakage goes to the cask pit, how long it will take for the cask pit boron concentration to go from 2500 ppm to 1700 ppm.

Per reference 7.2.5, the volume of the cask laydown pit is 23,326 gallons. This will be conservatively rounded down to 23,050 gallons. Next we will substract the volume of the DSC which is in the cask pit. Per reference 7.3.7, the DSC is a cylinder of radius 3.5625 feet and a length of 16.9167 feet. We will conservatively assume the DSC is a solid cylinder with no water in it. Therefore the volume of water displaced by the DSC is:
Volume=pi x (3.5625 feet)**2 x 16.9167 feet = 674.49 ft**3
Converting to gallons, 674.49 cuft x 7.48 gallons/cuft = 5045 gallons. This will be conservatively rounded up to 5050 gallons of water displaced.

Thus the net amount of water in the cask pit is 23050 gallons – 5050 gallons = 18000 gallons of water. If we conservatively assume a feed and bleed of the cask pit, where water enters the top of the cask pit, and water exits through the gate opening into the spent fuel pool, and we only credit the 18000 gallons of water in the cask pit, the dilution volume to go from 2500 ppm to 1700 ppm boron is:
Dilution Volume = 18,000 gallons * ln (2500/1700) = 6942 gallons, which is conservatively rounded down to 6900 gallons. Thus 6900 gallons of unborated water would have to be added directly to the top of the cask pit for the boron concentration to go from 2500 ppm to 1700 ppm, with complete mixing. There is no forced mixing in the cask pit. There is some mixing from thermal natural circulation due to the thermal load from the fuel in the bottom of the cask pit. However, since the unborated water is being added at the top of the pit, and the fuel is at the bottom of the pit, the boron concentration at the bottom of the pit where the fuel is, will be slower to change than if there was instantaneous complete mixing.

Thus it is estimated that 6900 gallons of unborated water would have to be added to the cask laydown pit to reduce the boron concentration near the fuel in the DSC from 2500 ppm to 1700 ppm, taking only credit for the water volume in the cask laydown pit. If there was a leak of 7 gpm from the PMW pipe upstream of valve 2-PMW-295, and all of the water flowed into the cask pit, it would take 6900/7 = 985 minutes = 16.4 hours for the cask pit boron concentration near the fuel to go from 2500 ppm to 1700 ppm. For reasons previously explained it is unlikely that all of the water leaking from the PMW pipe would make it to the cask pit, thus the value of 16.4 hours is conservative. Since every 3 hours, when a DSC with fuel is in the cask pit, the SFP level is being visually monitored, a leak into the cask pit would be evident. Termination of the PMW leak, even with an un-isolable leak located on the SFP operating deck, could be accomplished by shutting down the PMW pumps.

Thus, potential dilution of the cask laydown pit from the PMW hose station is prevented by:

(1) Ensuring that valves 2-PMW-295, 2-PMW-408 and 2-PMW-409 are closed if a DSC with fuel is to be left un-attended.

(2) During the visual verification every 3 hours that the SFP is not overflowing, it would be evident to the observer that there would be a leak with water flowing into the cask pit.

Summary of measures to minimize the possibility of direct dilution of the cask handling pit

In order to minimize the possibility of a direct dilution of the cask handling pit, with a DSC with fuel in the cask handling pit, the following measures will be administratively implemented:

(1) Valve 2-RW-350 (normally closed) must be closed to ensure that no spent fuel pool cooling flow goes to the cask laydown pit.
(2) Valves 2-PMW-295, 2-PMW-408 and 2-PMW-409 are to be closed if a DSC with fuel is in the cask laydown pit, and will be left un-attended.

4.0 DILUTION SOURCE PATH EVALUATION

This Section evaluates the potential for dilution of the SFP both from the SFP Cooling System as well as from external sources within the SFP building.

4.1 Spent Fuel Pool Cooling

There is limited potential for addition of water from systems that cross-connect into the SFP Cooling system. Potential water addition can be supplied from the Low Pressure Safety Injection (LPSI) system through the Shutdown Cooling Heat Exchangers. The borated water source being the Refueling Water Storage Tank (RWST) which is maintain at or above 1720 ppm boron (Ref.: 7.4.1 and 7.4.3). The RWST is also the source of water for the Refueling Pool Purification system at a transfer rate of 125 gpm. Both sources are isolated by a multiple of normally closed valves, 2-SI-458, 2-RW-15 and 2-RW-27 and either 2-RW-25 or 2-RW-28B depending which RW Purification Pump is in operation, and controlled procedurally by Operations (Ref.: 7.2.4 and 7.2.5). These systems are not a threat to dilute the SFP boron concentration to 1700 ppm since the injected water is from a borated water source with a concentration ≥ 1720 ppm.

4.2 Auxiliary Feedwater

The Auxiliary Feedwater (AFW) system takes suction from the Condensate Storage Tank (CST) and is a backup supply of makeup water with a flow rate of 100 gpm to the SFP. It is isolated by a normally locked closed valve, 2-FW-54, and controlled procedurally by Operations (Ref.: 7.2.3). The CST is a non-borated water source with a useable volume of 250,000 gallons (Ref.: 7.5.2). Makeup to the CST is a manual evolution that is performed by Operations and controlled by procedure (Ref.:7.2.3). Auxiliary Feedwater is not considered a dilution that will threaten reaching a SFP soluble boron concentration of 1700 ppm, since the flow rate of 100 gpm is less than the 200 gpm dilution flow rate of unborated water needed to dilute the SFP from 2500 ppm to 1700 ppm in 9.5 hours. Operators would be alerted to this event by a high SFP water level alarm, and as a backup, administrative procedures will require every 3 hours a visual check is made to verify the pool is not overflowing, whenever a DSC is in the SFP with fuel in the DSC. Therefore, a leak in the Auxiliary Feedwater system to the SFP is not considered a threat to dilute the SFP below 1700 ppm.

4.3 Primary Makeup Water

The Primary Makeup Water system is the normal makeup water supply to the SFP from the Primary Water Storage Tank (PWST). This is being supplied at a minimum rate of 50 gpm (Ref.: 7.5.1) which is adequate for the water loss due to evaporation and any system leakage that may occur. The Primary Makeup Water (PMW) System has a 150,000 gallon tank capacity (Ref.: 7.5.3). The maximum makeup capability of this permanently installed system is 200 gpm (Ref.: 7.5.1). This manipulation is a manual evolution that is performed by Operations and controlled by procedure (Ref.: 7.2.5). This is not considered a dilution that will threaten reaching a SFP boron concentration of 1700 ppm since the dilution flow rate of 200 gpm of unborated water would require 9.5 hours to dilute the SFP from 2500 ppm to 1700 ppm. Operators would be alerted to this event by a high SFP water level alarm, and as a backup, administrative procedures will require every 3 hours a visual check is made to verify the pool is not overflowing, whenever a DSC is in the SFP with fuel in the DSC.

4.4 RBCCW

The Reactor Building Closed Cooling Water (RBCCW) system provides coolant to the shell side of the SFP heat exchangers. The heat exchanger tubes form a physical barrier between the RBCCW and the SFP cooling systems. The pressures on the tube side and the shell side are nearly equal, with the RBCCW pressure slightly higher. If a tube leak/rupture were to occur, the RBCCW would enter the SFP cooling system, diluting the pool. The volume of the RBCCW is approximately 42,000 gallons (Ref.: 7.2.10), however, makeup to the RBCCW system surge tank is from the Primary Water System. The Primary Makeup Water (PMW) System has a 150,000 gallon tank capacity (Ref.: 7.5.3) and the PMW makeup pumps are capable of providing 200 gpm (Ref.: 7.5.1 and 7.12). Calculations (Ref: 7.2.1) show that the maximum dilution flow from a tube rupture in the SFP heat exchanger would be less than 142 gpm. This is not considered a dilution that will threaten reaching a SFP boron concentration of 1700 ppm since tube rupture flow rate of 142 gpm is less than the limiting dilution flow rate of 200 gpm of unborated water, which would require 9.5 hours to dilute the SFP from 2500 ppm to 1700 ppm. Operators would be alerted to this event by a high SFP water level alarm, and as a backup, administrative procedures will require every 3 hours a visual check is made to verify the pool is not overflowing, whenever a DSC is in the SFP with fuel in the DSC.

4.5 Filling the Transfer Canal

The transfer canal is normally full of borated water and open to the SFP. The gate that connects the SFP to the transfer canal will be procedurally required to be open when a DSC is in the spent fuel pool cask laydown area. By having the transfer canal open to the pool, this conservatively increases the water volume in the spent fuel pool to minimize the effects of any dilution.

Requiring the gate between the pool and the transfer canal to be open precludes the possibility of a drained transfer canal being filled with unborated water and then opened to the pool. If it was empty and needed to be filled, the transfer canal fill is accomplished by way of a batch process using water from the SFP. This process is controlled procedurally by Operations (Ref.: 7.2.5) and is currently performed by placing a submersible pump in the SFP, then raising the SFP level using water from the RWST (a borated water supply) to below the high level alarm in the SFP. Then the fill to the SFP is secured and the submersible pump is started, pumping SFP water to the transfer canal. This process is repeated until the transfer canal is at the desirable level. Once the fill process is completed, the canal bulkhead gate can be opened to equalize the two areas in support of refueling operations. Using this process, only borated water is used.

Even in the unlikely event that a unborated water source was used to fill the transfer canal, the volume is not sufficient to dilute the SFP to 1700 ppm. The transfer canal has a capacity of 76,387 gallons (Ref.: 7.2.5), which when combined with the small volumes within the transfer tube and bulkhead gate areas equals 78,405 gallons (Ref.: 7.2.5). This volume is less than the 114,000 gallons needed to dilute the SFP soluble boron concentration from 2500 ppm to 1700 ppm.

4.6 Filling the Cask Laydown Pit

The cask laydown pit is adjacent to the SFP and is isolated by a bulkhead gate. A spent fuel shipping cask can be placed in the SFP cask laydown pit for loading of fuel. The gate that connects the SFP to the cask laydown pit will be procedurally required to be open when a DSC is in the spent fuel pool cask laydown pit. Since the gate is procedurally required to be open, the pit can not be drained and re-filled with unborated water, ensuring it does not become a potential dilution source

5.0 PIPE BREAKS AND LEAKS

5.1 Pipe Break/Leak Methodology

Pipe break and leak methodology for boron dilution events in the Millstone 2 spent fuel pool was previously stated in reference 7.12 and provided to the NRC in reference 7.8.

5.2 Primary Water

The Primary Water Storage Tank supplies demineralized water to the SFP area (Ref.: 7.3.6). There is a primary water hose station, line 1 ½"-HCD-43, on the 38'-6" elevation north of the cask laydown area (Ref.: 7.3.6). The PWST, which supplies PMW, has a capacity of 150,000 gallons (Ref.: 7.5.3). Makeup to the PWST is a manual evolution and performed by Operations and controlled by procedure. This system is designed to seismic Class 2 requirements, but considered a moderate energy line and not postulated to crack under a seismic event (Ref.: 7.9). Even if this piping does develop a through wall crack of the size consistent with moderate energy line breaks, the leak flow rate is bounded by the leak rate for the fire protection system, which is 93 gpm. This maximum leak flow rate of 93 gpm is less than the 200 gpm dilution flow rate of unborated water needed to dilute the SFP from 2500 ppm to 1700 ppm in 9.5 hours. Operators would be alerted to this event by a high SFP water level alarm, or as a backup, administrative procedures will require every 3 hours a visual check is made to verify the pool is not overflowing, whenever a DSC is in the SFP with fuel in the DSC. Therefore, a leak in the Primary Water system is not considered a threat to dilute the SFP below 1700 ppm.

5.3 Auxiliary Steam and Condensate Return

The location of the Auxiliary Steam and Condensate Return piping on the 38'-6" elevation northwest and southwest areas of the SFP floor allows for the potential of diluting the SFP. The Auxiliary Steam system is a low pressure steam supply system with a normal operating pressure of 25 psig at 267 °F (Ref.: 7.1.1). The Auxiliary Steam and Condensate Return system meets the high energy line classification (piping systems with normal operating temperature equal to or greater than 200 °F, or normal operating pressure equal to or greater than 275 psig) (Ref.: 7.9). The worst case scenario would be a break in the 6x4 reducer at the southwest end of the SFP (Ref.: 7.3.1). After the break, steam would emit at sonic velocity as saturated steam, condense, then collect on piping, supports and other structures above the SFP floor. The water volume emitting as a result of this break calculates to 75.4 gpm (Ref.: 7.1.1). This maximum leak flow rate of 75.4 gpm is less than the 200 gpm dilution flow rate needed to dilute the SFP from 2500 ppm to 1700 ppm in 9.5 hours. Operators would be alerted to this event by a high SFP water level alarm, or as a backup, administrative procedures will require every 3 hours a visual check is made to verify the pool is not overflowing, whenever a DSC is in the SFP with fuel in the DSC. Therefore, a leak in the Auxiliary Steam and Condensate system is not considered a threat to dilute the SFP below 1700 ppm.

5.4 Fire Protection

Fire Protection (FP) System operation is such that a 50 gpm electric jockey pump (M7-11) maintains system pressure by automatically starting when line pressure drops to 105 psig and will run until pressure reaches 120 psig. An electric driven fire pump (P-82) is activated by a single pressure switch set at 85 psig. In the event this switch or pump fails to operate and line pressure continues to drop, the diesel-driven fire pump is activated by an additional pressure switch set at 75 psig. Both the electric and diesel-driven fire pumps deliver 2000 gpm at 100 psi discharge pressure and remain in operation until they are manually shut down. The fire pumps are supplied from two 245,000-gallon ground level suction tanks. The tanks are automatically filled through a water line fed from city water, so there is essentially an unlimited supply of water (Ref.: 7.5.4).

There are two hose stations (HS) on the 38'-6" elevation of the SFP floor that could potentially be a boron dilution path to the SFP, they are HS 230 and HS 226 (Ref.: 7.3.2).

The FP system is considered a Moderate Energy Line (MEL) because the system operating conditions are less than 200°F and less than 275 psig (Ref.: 7.9). Therefore, piping that meet these operating temperature and pressure limits, requires no postulation of breaks or cracks, based on the original MP2 licensing basis. The FP system HS's on the SFP floor area are being supplied from a 4 inch piping header. To quantify a volume and flow rate from the FP system, the MP2 Hazards Program makes reference to the Standard Review Plan (SRP) NUREG-0800 for guidance in assessing postulated pipe breaks and cracks. In Branch Technical Position ASB 3-1 (Ref.: 7.10), design breaks or cracks are calculated as ½ the pipe diameter in length and ½ the wall thickness in width. The FP system has been calculated to have a flow rate from a crack to be 93 gpm (Ref.: 7.1.1). This flow rate is less than the 200 gpm of unborated water determined in Section 3.0, which is needed to dilute the SFP boron concentration from 2500 ppm to 1700 ppm in 9.5 hours. Operators would be alerted to this event by a high SFP water level alarm, or as a backup, administrative procedures will require every 3 hours a visual check is made to verify the pool is not overflowing, whenever a DSC is in the SFP with fuel in the DSC. The minimum time of 9.5 hours will be more then adequate for operators to notice the alarms, and/or high SFP level condition, locate the source of the leak and isolate the water flow. Therefore, a leak in the Fire Protection system is not considered a threat to dilute the SFP below 1700 ppm

5.5 Domestic Water

The Domestic Water system is supplied from the city water supply which has several branch connections in the SFP area. This line, 2"-JDD-10 (Ref.: 7.3.3), is considered a moderate energy pipe and therefore, susceptible to the applicable rules for evaluating moderate energy piping for pipe breaks (Ref.:7.9). The Domestic Water system piping and operating parameters are less than the FP system. Even if this piping does develop a through wall crack of the size consistent with moderate energy line breaks, the leak flow rate is bounded by the leak rate for the fire protection system, which is 93 gpm. This maximum leak flow rate of 93 gpm is less than the 200 gpm dilution flow rate of unborated water needed to dilute the SFP from 2500 ppm to 1700 ppm in 9.5 hours. Operators would be alerted to this event by a high SFP water level alarm, or as a backup, administrative procedures will require every 3 hours a visual check is made to verify the pool is not overflowing, whenever a DSC is in the SFP with fuel in the DSC. Therefore, a leak in the Domestic Water system is not considered a threat to dilute the SFP below 1700 ppm.

5.6 Turbine Building Closed Cooling Water

The TBCCW system supplies water to the SFP Cooling Supplemental Cooling Heat Exchanger. The worst case scenario would be a break at the 3"-HBD-434 (Ref: 7.3.4) pipe tee as it enters through the south wall into the SFP area. TBCCW is considered a moderate energy system and therefore, susceptible to the applicable rules for evaluating moderate energy piping for breaks (Ref.:7.9). The TBCCW is a closed loop system with a volume of less than 13,000 gallons (Ref.: 7.2.2). Makeup to the TBCCW system is a manual evolution and performed by Operations and controlled by procedure. The TBCCW system piping and operating parameters are less than the FP system. Even if this piping does develop a through wall crack of the size consistent with moderate energy line breaks, the leak flow rate is bounded by the leak rate for the fire protection system, which is 93 gpm. This maximum leak flow rate of 93 gpm is less than the 200 gpm dilution flow rate of unborated water needed to dilute the SFP from 2500 ppm to 1700 ppm in 9.5 hours. Operators would be alerted to this event by a high SFP water level alarm, or and as a backup, administrative procedures will require every 3 hours a visual check is made to verify the pool is not overflowing, whenever a DSC is in the SFP with fuel in the DSC. Therefore, a leak in the TBCCW system is not considered a threat to dilute the SFP below 1700 ppm.

5.7 Roof Drains

The roof drain piping around the SFP is such that the roof drains route from the roof to two separate drain headers.

The 10" roof drain line travels along the south wall of the 38'-6" elevation. This 10" drain line is not seismically supported and any leakage from this line would drain onto the SFP floor. This line interconnects 6 roof drains from the south portion of the auxiliary building roof. Reference 7.1.1 showed that if the entire roof surface area of water drains into the pool, 51 inches of rainfall would be required to add 230,971 gallons to the pool. By proportion, a rainfall of 25 inches would be required to add 114,000 gallons to the pool. Since both a pipe leak and 25 inches of rain would be necessary, this unborated dilution source is not considered a credible threat to dilute the SFP soluble boron concentration from 2500 ppm to 1700 ppm.

The piping above the SFP is seismically supported (Ref.: 7.3.5) and therefore should not be a potential dilution source of water into the SFP. However, should there be a leak in this piping, the roof area supplying this drain piping is less than the non-seismic header. Therefore the required rainfall would be 25 inches or larger. Since both a pipe leak and 25 inches of rain would be necessary, this unborated dilution source is not considered a credible threat to dilute the SFP soluble boron concentration from 2500 ppm to 1700 ppm.

6.0 CONCLUSIONS

Criticality analysis (Ref.: 7.6) has shown that for limiting fuel enrichments/conditions in a 32PT DSC, which requires an initial soluble boron concentration of 2500 ppm to assure $k_{eff} < 0.95$ on a 95/95 basis, 1700 ppm of soluble boron is needed in the DSC to assure subcriticality on a 95/95 basis. This engineering analysis of scenarios which could dilute the boron concentration below 2500 ppm in the SFP/DSC demonstrates that sufficient time is available to detect and terminate a boron dilution prior to reaching 1700 ppm, thus ensuring sub-criticality in the 32PT DSC is maintained.

The systems that could dilute the spent fuel pool, either by direct connection to the spent fuel pool, or by a potential pipe crack/break have been analyzed. There is no automatic spent fuel pool level control system in the spent fuel pool, so that any dilution to the spent fuel pool will add water to the spent fuel pool. Therefore, the addition of unborated water to the SFP will lead to increased SFP water level, and if not controlled, an overflow of the SFP.

The ability to prevent the SFP soluble boron concentration from being diluted from the NUHOMS CofC 1004 TS minimum value of 2500 ppm to a value of 1700 ppm has been demonstrated by showing that each potential dilution source meets one of the following two criteria:

- Any dilution source not capable of supplying 114,000 gallons of unborated water will not be capable of diluting the SFP soluble boron concentration from 2500 ppm to 1700 ppm.
- If the dilution flow rate of unborated water is $\leq$ 200 gpm, then at least 9.5 hours will be needed for the SFP soluble boron concentration to be reduced from 2500 ppm to 1700 ppm. All dilution scenarios evaluated here will eventually cause SFP high water level alarms either detected directly by control room alarm, and as a backup, administrative procedures will require every 3 hours a visual check is made to verify the pool is not overflowing, whenever a DSC is in the SFP with fuel in the DSC. Since it takes 2 hours to overflow the pool, and every 3 hours a check is made to ensure the pool is not overflowing, the conservatively longest time to detect the dilution event is 5 hours. Since 9.5 hours are needed at 200 gpm to dilute the SFP soluble boron concentration to 1700 ppm, there is ample time, at least 4.5 hours, to terminate the dilution event.

The existing potential dilution sources are not credible threats to dilute the SFP soluble boron concentration from 2500 ppm to 1700 ppm due to either volume or flow rate considerations. The volume of unborated water needed to dilute the SFP soluble boron concentration from 2500 ppm to 1700 ppm has been conservatively calculated to be 114,000 gallons. Many of the potential dilution sources described in this report do not have volumes this large, and therefore are not capable of diluting the SFP boron concentration from 2500 ppm to 1700 ppm.

For those systems which have the potential to add in excess of 114,000 gallons of water to the SFP, a dilution flow rate in excess of 200 gpm of unborated water would be necessary for 9.5 hours to cause a dilution of the SFP soluble boron concentration from 2500 ppm to 1700 ppm. The operators will be alerted to this by high SFP water level alarms in the control room, or as a backup, administrative procedures will require every 3 hours a check is made to verify the pool is not overflowing, whenever a DSC is in the SFP with fuel in the DSC. Since it takes 2 hours to overflow the pool, and every 3 hours a check is made to ensure the pool is not overflowing, the conservatively longest time to detect the dilution event is 5 hours. Since 9.5 hours are needed at 200 gpm to dilute the SFP soluble boron concentration to 1700 ppm, there is ample time, at least 4.5 hours, to terminate the dilution event.

The largest identified dilution flow rate (for any system with a potential dilution volume of at least 114,000 gallons) was 200 gpm of Primary Makeup Water from the PWST delivered directly to the SFP as a manual makeup source to the SFP. Assuming 200 gpm of unborated Primary Makeup Water is emitted into the SFP, it would take 9.5 hours (Ref.: Section 3.0) to yield the 114,000 gallons necessary to reduce the SFP boron concentration from 2500 ppm to 1700 ppm.

If an inadvertent dilution of the SFP occurs using Primary Makeup Water directly to the SFP, the operators will be alerted to this by a high SFP water level alarm in the control room, or as a backup, administrative procedures will require every 3 hours a check is made to verify the pool is not overflowing, whenever a DSC is in the SFP with fuel in the DSC. Since it takes 2 hours to overflow the pool, and every 3 hours a check is made to ensure the pool is not overflowing, the conservatively longest time to detect the dilution event is 5 hours. Since 9.5 hours are needed at 200 gpm to dilute the SFP soluble boron concentration to 1700 ppm, there is ample time, at least 4.5 hours, to terminate the dilution event.

In order to ensure that proper mixing is available during potential dilution events, a minimum of 850 gpm of SFP cooling flow will be required when there is a DSC with fuel in the cask laydown pit. In order to ensure that the possibility of direct cask pit dilutions are minimized the following 2 requirements will be implemented: (1) Valve 2-RW-350 (normally closed) must be closed to ensure that no spent fuel pool cooling flow goes to the cask laydown pit, and (2) Valves 2-PMW-295, 2-PMW-408 and 2-PMW-409 are to be closed if a DSC with fuel is in the cask laydown pit, and will be left un-attended.

An additional check was performed if the required boron concentration was 1800 ppm for the 32PT DSC. Criticality analysis (Ref.: 7.6) has shown that for limiting fuel enrichments/conditions in a 32PT DSC, which requires an initial soluble boron concentration of 1800 ppm to assure $k_{eff} < 0.95$ on a 95/95 basis, 1200 ppm of soluble boron is needed in the DSC to assure subcriticality on a 95/95 basis. The volume of unborated water for a dilution from 1800 to 1200 ppm is more than the volume of water required for a dilution from 2500 to 1700 ppm. Therefore, the dilution from 2500 ppm to 1700 ppm is more restrictive (gives shorter dilution times) and is the limiting case.

In summary, this engineering analysis of scenarios which could dilute the boron concentration below 2500 ppm in the SFP/DSC demonstrates that sufficient time is available to detect and terminate a boron dilution prior to reaching 1700 ppm, thus ensuring sub-criticality in the 32PT DSC is maintained.

7.0 REFERENCES

7.1 Calculations

- 7.1.1 MP2SFP-03034, Unit 2 SFP Potential Dilution Sources, Rev. 0, approved 10/16/01, and CCN 1, approved 12/8/04
- 7.2.1 S-0409252, MP2 Spent Fuel Pool Heat Exchanger Tube Rupture Analysis, Rev. 0, approved 9/13/04.

7.2 Procedures

- 7.2.1 ARP 2590E-071, revision 0, Alarm Response for SFP Level HI
- 7.2.2 Chem Form, 2802E-6, Hydrazine Addition to TBCCW and Chill Water, Rev. 1, issued 2/21/98
- 7.2.3 OP 2322, Auxiliary Feedwater System, Rev. 25, Ch. 2
- 7.2.4 OP 2307, Low Pressure Safety Injection, Rev. 12, Ch. 8
- 7.2.5 OP 2305, Spent Fuel Pool Cooling and Purification System, Rev. 19, Ch. 12.
- 7.2.6 Not used
- 7.2.7 Not Used
- 7.2.8 Not Used
- 7.2.9 Not Used
- 7.2.10 Chem Form, 2802E-5, Hydrazine Addition to RBCCW, Rev. 1

7.3 Drawings

- 7.3.1 25203-26026 Sh. 2 of 4, P&ID Auxiliary Steam and Condensate, Rev. 19, issued 4/12/01
- 7.3.2 25203-26011 Sh. 1, P&ID Fire Protection System, Rev. 35, issued 4/23/01
- 7.3.3 25203-26011 Sh. 2, P&ID Domestic Water, Rev. 36, issued 8/14/01
- 7.3.4 25203-26007 Sh. 1, P&ID TBCCW, Rev. 16, issued 6/19/01
- 7.3.5 25203-24023, Roof Drain Auxiliary Building Plan, Rev. 2, issued 4/6/97
- 7.3.6 25203-26030 Sh.1, P&ID Water Treatment System, Rev. 40, issued 8/10/01
- 7.3.7 NUHOMS FSAR NUH-003, Appendix E-3, Drawing NUH-03-8002-SAR sheet 1 of 3 Rev 7

7.4 Unit 2 Technical Specifications

- 7.4.1 LCO 3.1.2.7
- 7.4.2 LCO 3.9.17
- 7.4.3 LCO 3.1.2.8
- 7.4.4 LCO 3.9.12
- 7.4.5 Design Feature 5.6.1

7.5 Unit 2 Final Safety Analysis Report

- 7.5.1 9.5.2, Spent Fuel Pool Cooling, System Description
- 7.5.2 10.4.5.3, Condensate and Feedwater System Description
- 7.5.3 9.12.2, Water Treatment System Description
- 7.5.4 9.10.2, Fire Protection System Description

7.5.5 9.8.2.1.2, Spent Fuel Storage
7.5.6 Table 9.5-1

7.6 Transnuclear Calculation 10499-01, revision 0, Boron Dilution Criticality Analysis for NUHOMS-32PT

7.7 Not Used

7.8 Letter from Millstone to US NRC, 11/6/2001, B18501, Technical Specification Change Request (TSCR) 2-10-01, Fuel Pool Requirements.

7.9 Specification SP-M2-ME-003, Pipe Rupture Analysis Criteria Outside the Reactor Building - Millstone Unit 2, Rev. 1, dated 4/28/98

7.10 SRP NUREG-0800 Section 3.6.1, Plant Design for Protection Against Postulated Piping Failures in Fluid Systems Outside Containment, Rev. 1, dated 7/1981

7.11 SRP NUREG-0800 Section 3.6.2, Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping, Rev. 1, dated 7/1981

7.12 Technical Evaluation M2-EV-01-0018, revision 0, 10/17/01, Spent Fuel Pool Dilution Analysis Summary.

7.13 Amendment 7 to Certificate of Compliance Number 1004 for the Transnuclear Standardized NUHOMS System.

7.14 Amendment 9 to Certificate of Compliance Number 1004 for the Transnuclear Standardized NUHOMS System.

7.15 Amendment 274 to Millstone 2 Operating License, 4/1/2003, TAC NO. MB3386, A15859

Approved 8/27/02 Effective 8/30/02

ATTACHMENT 2

Independent Reviewer Comment and Resolution Sheet(s)

(ER/EV) No. M2-EV-04-0025 Revision 1

Independent Reviewer: Tom Guarino Date

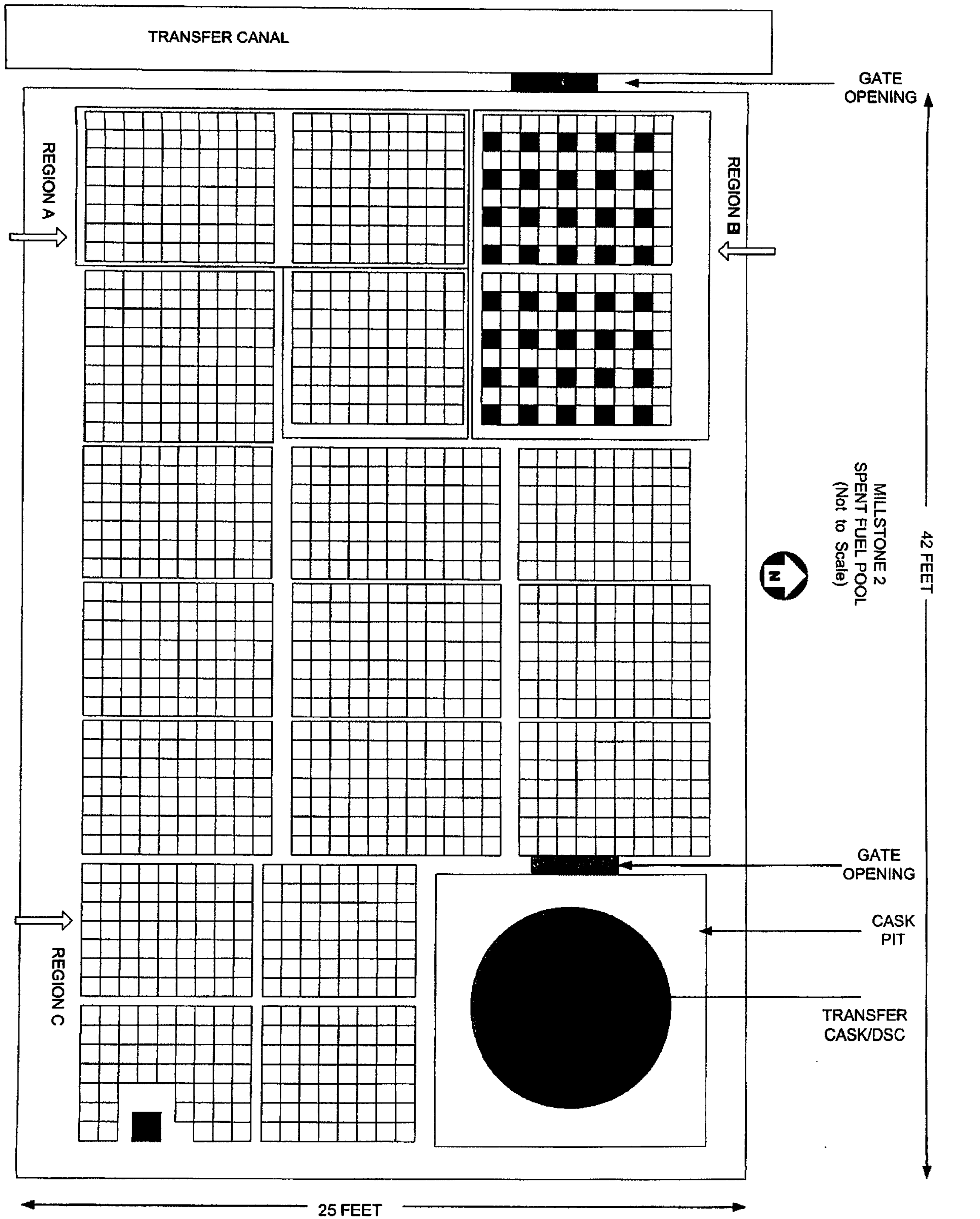
Comment No.	ER/EV Section	Comment
		No Comment T. Guarino 12/15/04

Attachment 4

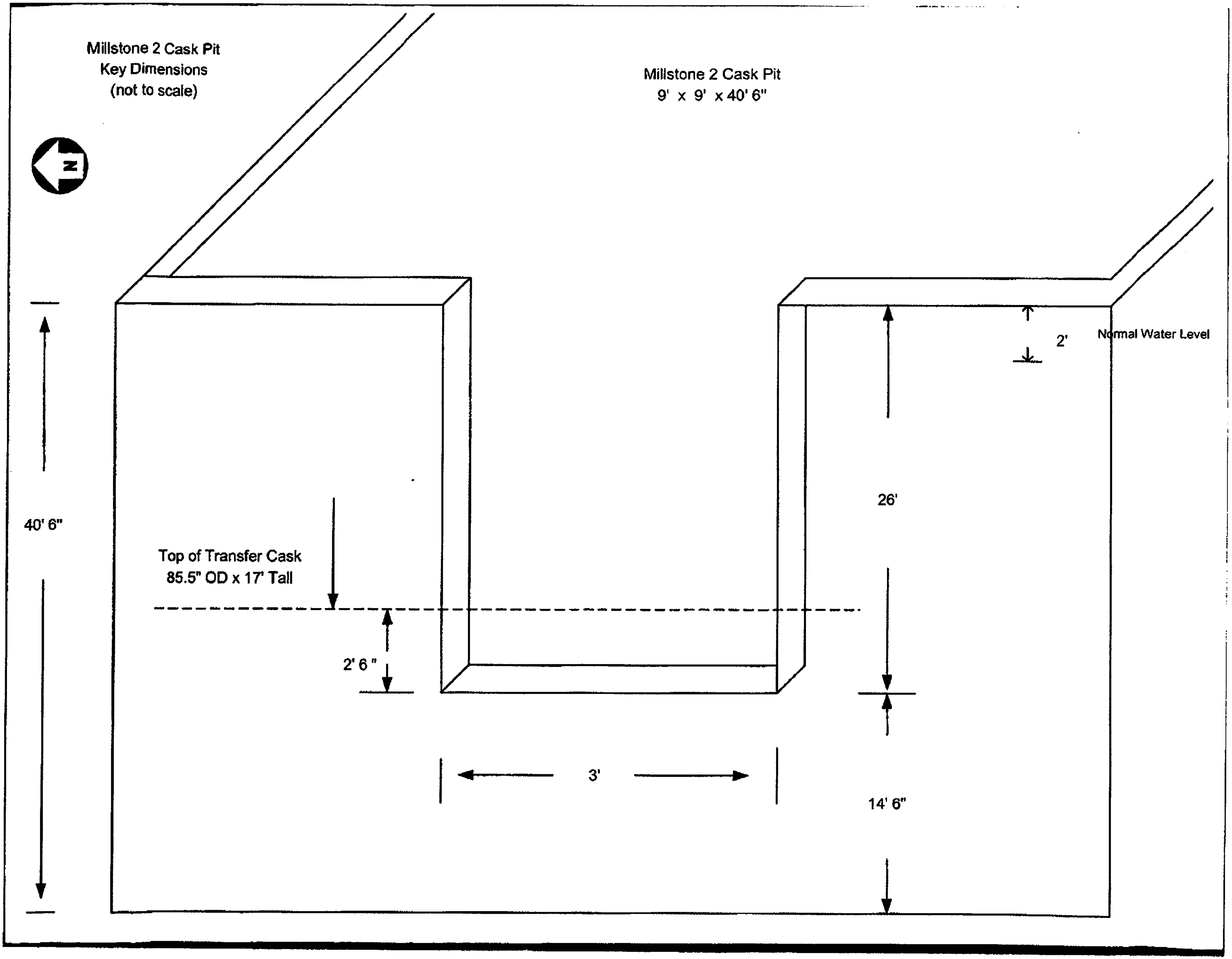
Reconciliation of Regulatory Requirements

Sketches of The Millstone 2 Spent Fuel Pool and Cask Pit

Millstone Power Station Unit 2
Dominion Nuclear Connecticut, Inc. (DNC)



TRANSFER CANAL
GATE OPENING
REGION A
REGION B
MILLSTONE 2 SPENT FUEL POOL (Not to Scale)
N
42 FEET
GATE OPENING
CASK PIT
TRANSFER CASK/DSC
REGION C
25 FEET


Millstone 2 Cask Pit
Key Dimensions
(not to scale)
Millstone 2 Cask Pit
9' x 9' x 40' 6"
N
Normal Water Level
2'
26'
40' 6"
Top of Transfer Cask
85.5" OD x 17' Tall
2' 6 "
3'
14' 6"