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February 28, 2008

U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001
ATTENTION: Document Control Desk

SUBJECT: Duke Energy Corporation
McGuire Nuclear Station, Units 1 and 2
Docket Nos. 50-369 and 50-370
NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors"

On September 13, 2004, the Nuclear Regulatory Commission (NRC) issued Generic Letter (GL) 2004-02. The GL requested that all pressurized-water reactor (PWR) licensees (1) evaluate the adequacy of the emergency sump recirculation function with respect to potentially adverse effects associated with post-accident debris, and (2) implement any plant modifications determined to be necessary.

By letter dated March 1, 2005, as supplemented by letter dated September 1, 2005, Duke Power Company LLC d.b.a. Duke Energy Carolinas, LLC (Duke) provided responses to GL 2004-02. By letter dated February 9, 2006, the NRC determined that additional information was necessary in order for the Staff to complete their review of McGuire's information. McGuire's responses to these requests for additional information are contained in Enclosure 1.

On November 30, 2007, the NRC issued a letter to the Nuclear Energy Institute authorizing all PWR licensees up to two months beyond December 31, 2007 (i.e., to February 29, 2008), to provide the supplemental responses to the NRC.

Additionally, by letter dated November 21, 2007, the NRC staff issued a revised "Content Guide for Generic Letter 2004-02 Supplemental Responses" for the use by PWR licensees in developing their GL 2004-02 responses. McGuire's supplemental responses are contained in Enclosure 2.

As stated by Duke's letter of November 6, 2007, as amended by letter dated December 13, 2007, any additional or revised information resulting from the

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Integrated Prototype (chemical effects) Testing will be provided as an amended response to GL 2004-02 by April 30, 2008. This extension was approved by the staff in a letter dated December 28, 2007. Additionally, as requested within this approval letter, Duke will provide additional information related to the NRC staff-requested evaluation of WCAP-16406, Revision 1 dated August 2007.

Duke understands that the NRC staff will consider this set of additional information and will issue a letter to Duke Energy assessing the overall adequacy of the McGuire Station's GL 2004-02 corrective actions.

If any questions arise or additional information is needed, please contact K. L. Ashe at (704) 875-4535.

Very truly yours,

Bruce Hamilton

Bruce H. Hamilton

Enclosures

Bruce H. Hamilton affirms that he is the person who subscribed his name to the foregoing statement, and that all the matters and facts set forth herein are true and correct to the best of his knowledge.

Bruce Hamilton

Bruce H. Hamilton, Vice President, McGuire Nuclear Station

Subscribed and sworn to me: 2-28-08
Date

Kay L Crane Kay L Crane, Notary Public

My commission expires: 4-1-2012
Date

SEAL

KAY L. CRANE
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Enclosure 1

Response to Request for Additional Information

Request for Additional Information 1
Identify the name and bounding quantity of each insulation material generated by a large-break loss-of-coolant accident (LBLOCA). Include the amount of these materials transported to the containment pool. State any assumptions used to provide this response.

McGuire Response:
General Note:
This RAI response describes the initial, unrefined quantities of insulation debris used in the baseline evaluation for sizing the McGuire ECCS sump strainer. Refined quantities of fibrous insulation debris used in design validation will be addressed as stated in response to RAI 12 of Enclosure 1.

Table 1-1 is a summary of the McGuire Nuclear Station insulation debris generated and transported to the ECCS sump by a large break loss of coolant accident. The limiting case is the "B" loop hot leg break.

Table 1-1
Insulation Debris Values

Debris Type	Break Zone of Influence (ZOI)	Debris Quantity Generated	Debris Transport Fraction (DTF)	Quantity At Sump
Insulation (Nukon® and Thermal-Wrap®) Low Density Fiberglass (LDFG)				
Fines	17D	272.7 ft^3	100%	272.7 ft^3
Small Pieces (<6" on a Side)	17D	891.9 ft^3	21%	187.3 ft^3
Large Pieces (>6" on a Side)	17D	444.9 ft^3	10%	44.5 ft^3
Intact Blankets	17D	476.4 ft^3	0%	0 ft^3
Reflective Metal Insulation (RMI)				
Small Pieces (<4")	28.6D	22,246 ft^2	0%	0 ft^2
Large Pieces (≥4")	28.6D	9,087 ft^2	0%	0 ft^2

Note: Only insulation debris is addressed in this RAI response. The quantities of failed coatings that transport to the ECCS sump are addressed separately in Enclosure 2, Section 3(h). Latent debris quantities (fiber fines, dust/dirt fines, tags/labels) that transport to the ECCS sump are addressed in Enclosure 2, Section 3(d).

The following assumptions have been made regarding debris generation:

1. It was assumed that buckles, straps, and wires securing insulation would not transport, and therefore can be excluded from the debris source term. These materials are metal based, and would readily sink to the floor. Also, the volume of these materials is negligible compared to the insulation volume.

2. It was assumed that all jacketed insulation outside of the ZOI would not undergo any erosion by either break or spray flows, i.e., no insulation debris would be generated outside of the postulated ZOIs.

3. Since RMI is not a significant contributor to head loss compared to a fibrous debris bed, an exact quantification of RMI for the break was not required. Large equipment (reactor coolant pumps and pressurizer) and large bore piping, e.g., RCS, Main Steam, Feedwater, and Auxiliary Feedwater, were considered in the tabulation of RMI. Even if the foil area of the RMI is significantly changed, its contribution to the total sump strainer head loss is negligible.

4. Thermal-Wrap® is a low density fiberglass insulation similar to Nukon®. The material characteristics, as well as destruction pressure and associated ZOI, are assumed equal to those defined for Nukon®.

The following assumptions have been made regarding <u>debris transport</u>:

5. NUKON® and Thermal-Wrap® are identical for transport purposes. This is a reasonable assumption since both products are low density fiberglass with similar material properties.

6. It was assumed that small pieces of fiberglass (smaller than 6") can be treated as 1" clumps, and large pieces can be treated as 6" pieces for transport purposes. This is a conservative assumption since smaller pieces of fiberglass transport more readily than larger pieces.

7. It was assumed that 1/4" - 4" pieces of RMI can be treated as 1/2" pieces, and 4"- 6" pieces can be treated as 2" pieces for transport purposes. This is a conservative assumption since smaller pieces of RMI transport more readily than larger pieces.

8. It was assumed that RMI would not break down into smaller pieces following the initial generation. This is a reasonable assumption since RMI is a metallic insulation that would not be subject to erosion by the flow of water.

9. It was assumed that the settling velocity of fine debris (insulation, dirt/dust, and paint particulate) can be calculated using Stokes' law. This is a reasonable

assumption since the particulate is generally spherical and would settle slowly (within the applicability of Stokes' law).

10. Based on fibrous debris testing, it was assumed that the fiberglass debris would not float in the containment pool. Test data has shown that fiberglass insulation sinks more readily in hotter water. Therefore, given the initial high temperature of the containment pool at McGuire (190°F), this is a reasonable assumption.

11. It was conservatively assumed that all of the debris generated by the postulated letdown line break would be transported to the sump (the letdown line break is not limiting even with this conservative assumption).

12. It was assumed that the fine debris was uniformly distributed in the pool at the beginning of recirculation.

13. With the exception of the debris blown through the crane wall penetrations, it was assumed that small and large piece debris would be uniformly distributed inside the crane wall.

14. It was assumed that the recirculation transport fractions determined for the Loop "B" break can be applied to the other breaks inside the crane wall. This is conservative, since the Loop "B" is closest to the sump.

15. Water falling from the reactor coolant system was conservatively assumed to do so without encountering any structures before reaching the containment pool.

16. It was assumed that a fraction of the fine debris as well as the small and large piece debris would be carried through the crane wall penetrations to the pipe chase in proportion to the blowdown flow split to the pipe chase.

17. It was conservatively assumed that all debris blown into the ice condenser would be subsequently washed back down with the melting ice flow.

18. For the Computational Fluid Dynamics (CFD) model, it was assumed that potential upstream blockage points (e.g. drains, grating, etc.) would not inhibit the flow of water through these areas.

Request for Additional Information 2
Identify the amounts (i.e., surface area) of the following materials that are:

a. submerged in the containment pool following a loss-of-coolant accident (LOCA),

b. in the containment spray zone following a LOCA:

- **aluminum**
- **zinc (from galvanized steel and from inorganic zinc coatings)**
- **copper**
- **carbon steel not coated**
- **uncoated concrete**

Compare the amounts of these materials in the submerged and spray zones at your plant relative to the scaled amounts of these materials used in the Nuclear Regulatory Commission (NRC) nuclear industry jointly-sponsored Integrated Chemical Effects Tests (ICET) (e.g., 5x the amount of uncoated carbon steel assumed for the ICETs).

McGuire Response:
General note:
The published results of ICET Test #5 were used in developing the input parameters of the Integrated Prototype Test (IPT) described in the response to RAI #11 of Enclosure 1. ICET Test #5 is not used directly to assess the chemical effects on the McGuire strainer head loss. The Duke IPT is a separate, comprehensive chemical effects test that emulates a portion of the ICET Test #5 battery, using bounding and representative chemical and debris input parameters that vary as a function of the ECCS mission time (to simulate the effects of spray) and are more closely coupled to the predicted McGuire post-LOCA environment.

The following is an assessment of the amount of the materials identified by RAI #2 located in the submerged zone (i.e., in the containment sump pool) in the post-LOCA environment at McGuire:

- *Aluminum*
  A bounding estimate of the amount of aluminum expected to be submerged in the containment sump pool following a LOCA is 530 square feet.
- *Zinc (from galvanized steel and from inorganic zinc coatings)*
  In an ice condenser containment such as McGuire, the galvanized steel components (e.g., baskets and structural steel) located within the boundary of the ice condenser itself are outside both the submergence and the containment spray zones. The total remaining estimated zinc inventory, in the form of metallic coatings, zinc based coatings, and electrical components and

equipment, is conservatively estimated at 543,700 square feet. A bounding estimate of the amount of this remaining inventory expected to be submerged in the post-LOCA containment pool is 142,800 square feet.

- *Copper*
  The copper inventory inside containment is not specifically tracked at McGuire.
- *Uncoated carbon steel*
  The uncoated carbon steel surface area inside the McGuire containments is not specifically tracked.
- *Uncoated concrete*
  Uncoated concrete surface areas inside the containments at McGuire are not specifically tracked. In general, all concrete surfaces inside containment are coated; however, there are some inaccessible areas that cannot be confirmed to have coatings (e.g., clearance between concrete expansion joints, the cavity between the reactor vessel and bio-shield wall). Since the majority of the ECCS sump is coated, only a minor fraction of uncoated concrete surface area would be submerged in the post-LOCA containment sump pool.

The following is an assessment of the amount of the materials identified by RAI #2 located in the spray zone (i.e., not submerged in the containment sump pool, but exposed to containment spray flow) in the post-LOCA environment at McGuire:

- *Aluminum*
  A bounding estimate of the amount of aluminum identified as in the spray zone following a LOCA is 740 square feet.
- *Zinc (from galvanized steel and from inorganic zinc coatings)*
  There is estimated to be 100,900 square feet of zinc inventory in the spray zone following a LOCA (i.e., miscellaneous galvanized steel and electrical support components). There is 300,000 square feet of top-coated zinc primers (qualified coatings) that are not considered a contributor to post-LOCA containment pool chemistry. Qualified coatings are only a containment pool particulate debris concern in the limiting LBLOCA coatings ZOI.
- *Copper*
  The copper inventory inside containment is not specifically tracked at McGuire.
- *Uncoated carbon steel*
  The uncoated carbon steel surface area inside the McGuire containments is not specifically tracked.

- *Uncoated concrete*
  Uncoated concrete surface areas inside the containments at McGuire are not specifically tracked. In general, all concrete surfaces inside containment are coated, however there are some inaccessible areas that cannot be confirmed to have coatings (e.g., clearance between concrete expansion joints, the cavity between the reactor vessel and bio-shield wall). While some fraction of this uncoated concrete will be above the ECCS sump and in the containment spray zone, the relative inaccessibility of this uncoated concrete surface area minimizes the effect of containment spray exposure.

A comparison of the expected amounts of these materials in the submerged containment pool zones relative to the scaled amounts of these materials used in ICET Test #5 (for ice condenser plants) is summarized in Table 2-1.

A comparison of the expected amounts of these materials exposed to containment spray (i.e., unsubmerged) does not yield additional McGuire/ICET Test #5 comparison information beyond that depicted in Table 2-1.

The expected McGuire post-LOCA containment sump pool chemistry (boron concentration, buffering agent concentration, and pH) is compared to the ICET Test #5 conditions in the response to RAI #6 of Enclosure 1.

Table 2-1
McGuire Values vs. ICET Test #5 Values

Parameter	MNS Values			Values used in ICET Test #5	
	Amount (total submerged + exposed to spray)**	**Amount Submerged** (from bounding estimates)**	**Ratio***	**Test Ratio**	**Submerged Material**
Aluminum	1300 ft^2	600 ft^2 (46%)	0.03 ft^2/ft^3	3.5 ft^2/ft^3	5%
Zinc in Galvanized Steel	250,000 ft^2	150,000 ft^2 (60%)	7.4 ft^2/ft^3	8.0 ft^2/ft^3	5%
Inorganic Zinc Primer Coatings (non-top coated)	See Note 1	See Note 1	-	4.6 ft^2/ft^3	4%
Copper (including Cu-Ni alloys)	Not Tracked (see Note 2)	Not Tracked (see Note 2)	-	6.0 ft^2/ft^3	25%
Carbon Steel	Not Tracked (see Note 3)	Not Tracked (see Note 3)	-	0.15 ft^2/ft^3	34%
Concrete (surface, uncoated)	Not Tracked (see Note 4)	Not Tracked (see Note 4)	-	0.045 ft^2/ft^3	34%

* McGuire minimum ECCS sump pool volume used (20,234 cubic feet) to maximize the ratio for ICET Test #5 comparison.
** These values are rounded up from the values in the response to RAI #2 for comparison purposes to the ICET Test #5 scaled amounts.

Note 1:
McGuire does not utilize inorganic zinc coatings, therefore the material is not considered in this comparison.

Note 2:
As demonstrated during ICET Test #5 and as identified in WCAP-16530-NP, copper and Cu-Ni alloys are resistant to corrosion under expected post-accident conditions and appear in only trace amounts in the predicted sump pool chemistry.

Note 3:
Carbon steel is a metal alloy primarily composed of iron. As demonstrated during ICET Test #5, iron appears in only trace amounts in the predicted sump pool chemistry[10]. Further, it was identified in WCAP-16530-NP that the release rates for iron were small and subsequently ignored in chemical effects precipitation modeling.

Note 4:
Uncoated concrete occurs in limited amounts in containment. As demonstrated during ICET Test #5, concrete is primarily a particulate debris concern in the McGuire post-LOCA containment sump pool. Further, sensitivity tests performed under WCAP-16530-NP determined that the precipitation of materials from concrete dissolution was negligible even with high exposed surface areas.

Based on the above assessments of the amount of the materials identified in RAI #2, the predicted post-LOCA conditions at McGuire compare reasonably and conservatively to the parameters and conditions tested in ICET Test #5. As noted earlier, the results from ICET Test #5 were used to help develop input parameters for Duke's Integrated Prototype Test for chemical effects.

Request for Additional Information 3

Identify the amount (surface area) and material (e.g., aluminum) for any scaffolding stored in containment. Indicate the amount, if any, that would be submerged in the containment pool following a LOCA. Clarify if scaffolding material was included in the response to Question 2.

McGuire Response:

McGuire does not permanently store scaffold materials inside containment.

On occasion, scaffolds may be temporarily installed in containment during power operations to support specific maintenance activities. Installation of temporary scaffolding is procedurally controlled. Aluminum inventory related to temporary scaffolding installed inside containment is logged and compared to administrative limits to ensure that the limits are not exceeded. Margin is included in the aluminum values provided in the response to RAI #2 of Enclosure 1 for temporary scaffolding applications.

Zinc (associated with galvanized coatings on certain scaffolding components) is primarily a particulate concern in the post-LOCA ECCS sump pool and is an insignificant contributor to post-LOCA sump chemistry. There is substantial margin in the inventory limit for zinc inside containment; therefore, the zinc coatings associated with temporary scaffolding is not a specifically tracked element.

Request for Additional Information 4
Provide the type and amount of any metallic paints or non-stainless steel insulation jacketing (not included in the response to Question 2) that would be either submerged or subjected to containment spray.

McGuire Response:
All insulation jacketing materials inside containment are stainless steel.

The only known metallic paint, other than zinc-based primers, is associated with touch-up coatings on galvanized steel items. This coating application has had very limited use and has been accounted for as an unqualified coating. Galvanized steel items are accounted for in the response to RAI #2 of Enclosure 1.

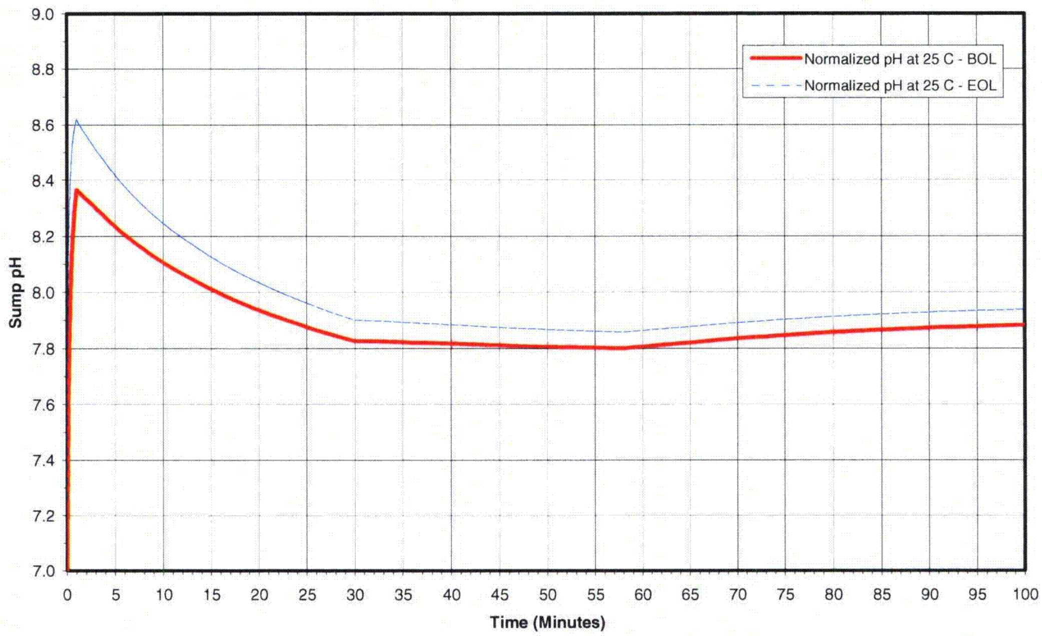
Request for Additional Information 5
Provide the expected containment pool pH during the emergency core cooling system (ECCS) recirculation mission time following a LOCA at the beginning of the fuel cycle and at the end of the fuel cycle. Identify any key assumptions.

McGuire Response:
In order to establish the containment sump pool pH at a particular time after the initiation of a postulated LBLOCA event, the addition of water to the sump from the various Emergency Core Cooling System (ECCS) sources and the Ice Condenser must be established. The guidance from NUREG/CR-5950 was followed. Major inputs and assumptions used in the McGuire Nuclear Station ECCS sump pH calculation are provided in Table 5-1 below. LBLOCA is considered because of the large potential for debris generation.

An analysis was performed to document how the ECCS sump pH was affected by both Beginning-of-Life (BOL) and End-of-Life (EOL) boron concentrations in the reactor coolant inventory. The EOL scenario, consisting of much lower concentrations of boron in the reactor coolant inventory, yields a higher sump pH profile than the same analysis for the BOL assessment. Figure 5-1 shows the time-dependent sump pH profile for both BOL and EOL cases, normalized to 25 °C.

The McGuire ECCS sump pH analysis shows that by 2 hours after LBLOCA initiation all of the water from the RCS, Refueling Water Storage Tank (FWST), Cold Leg Accumulators (CLAs), and the ice melt from the Ice Condenser will be in the sump. Continuing nitric acid and hydrochloric acid production due to irradiation of the water/air mixture and of the electrical cable insulation/jacket material inside containment will be a long term contributor to the pH value of the sump. In order to address the impact of this effect, a sensitivity analysis was performed and showed that when the time range is expanded beyond 2 hours, there is an insignificant change in the ECCS sump pH.

Figure 5-1
McGuire LBLOCA Expected Beginning and End of Life Sump pH Response



Key Assumptions:

Table 5-1
Key Assumptions For the Calculation of Post LOCA Containment Sump pH at McGuire Nuclear Station

Input Description	Value
Reactor Coolant Inventory	11,114.4 ft^3
Boron Content in Reactor Coolant (BOL)	1220.5 ppm
Boron Content in Reactor Coolant (EOL)	9.0 ppm
FWST Inventory	346,606 gal
Boron Content in FWST	2775 ppm
Cold Leg Accumulators Volume	3800 ft^3
Boron Content in Cold Leg Accumulators	2675 ppm
Ice Condenser Mass	1,890,180 lbm
Ice Condenser Boron Content	2065 ppm

Request for Additional Information 6

For the ICET environment that is the most similar to your plant conditions, compare the expected containment pool conditions to the ICET conditions for the following items: boron concentration, buffering agent concentration, and pH. Identify any other significant differences between the ICET environment and the expected plant-specific environment.

McGuire Response:

Post-LOCA containment sump pool chemistry is a function of Reactor Coolant System (RCS)/Emergency Core Cooling System (ECCS)/Ice Condenser inventory chemistry, and also a function of the chemical effects due to materials submerged in the pool (and sprayed outside the pool) during the ECCS mission time. The response to RAI #2 of Enclosure 1 addresses materials in the containment pool and the response to RAI #5 of Enclosure 1 specifically addresses the pH of the containment pool. The multi-part pool chemistry comparison requested in this RAI invokes the previous pH response, so that information is repeated here (in a different form) for consistency.

McGuire is an ice condenser plant using sodium tetraborate as the buffering agent. It has no calcium silicate insulation material. Therefore, the ICET environment that is most similar to McGuire is ICET Test #5. A comparison of the expected McGuire containment pool conditions and ICET Test #5 conditions at fuel cycle Beginning-of-Life (BOL) and End-of-Life (EOL) is provided in Table 6-1:

Table 6-1
McGuire Containment Pool Conditions vs. ICET Test #5 Conditions

	McGuire BOL	McGuire EOL	ICET Test 5
Boron Concentration (ppm B)	1703 to 2487 ≥2013 after 1 minute 2478 after 110 minutes	898 to 2372 >1592 after 1 minute 2370 after 88 minutes	2400
pH (normalized to 25C)	6.55 to 8.37 <8 after 16 minutes 7.83-7.89 after 67 minutes	7.04 to 8.62 <8 after 23 minutes 7.88-7.94 after 64 minutes	8 to 8.5
Na concentration from sodium tetraborate (ppm Na)	755 after 110 minutes > 465 after 18 seconds	755 after 110 minutes > 465 after 18 seconds	1200 to 1400

Based on the comparison above, ICET Test #5 parameters are representative of or bound the predicted McGuire post-LOCA environment parameters.

Request for Additional Information 7
For a LBLOCA, provide the time until ECCS external recirculation initiation and the associated pool temperature and pool volume. Provide estimated pool temperature and pool volume 24 hours after a LBLOCA. Identify the assumptions used for these estimates.

McGuire Response:
For LBLOCA the time until ECCS external recirculation initiation and the associated pool temperatures and pool volumes are shown in the table below.

Table 7-1
ECCS Parameters After LBLOCA

Analysis Assumptions	Time	Sump Temperature (°F)	Sump Volume (ft^3)
Minimum Safeguards (Note 1)	1579 seconds to recirc. initiation	185	46,916
	24 hours	145	57,819
Maximum Safeguards (Note 2)	806 seconds to recirc. initiation	189	43,352
	24 hours	114	59,972

Note 1: Minimum Safeguards conditions are characterized by minimum flow rates from one train of ECCS pumps, including one containment spray pump.

Note 2: Maximum Safeguards conditions are characterized by maximum flow rates from two trains of ECCS pumps, including two containment spray pumps.

<u>**Request for Additional Information 8**</u>
Discuss your overall strategy to evaluate potential chemical effects including demonstrating that, with chemical effects considered, there is sufficient net positive suction head (NPSH) margin available during the ECCS mission time. Provide an estimated date with milestones for the completion of all chemical effects evaluations.

<u>McGuire Response:</u>
Duke's overall strategy to evaluate chemical effects employs an Integrated Prototype Test (IPT) that is designed to simulate the predicted comprehensive challenge to the McGuire and Catawba ECCS Strainers in the post-LOCA containment pool. The IPT combines the physical and chemical characteristics expected in the post-accident environment, and then challenges a prototype strainer module in this environment for the full 30-day ECCS mission time. Overall characteristics of the IPT are identified below:

- Full-scale strainer top-hat module
- Representative debris load (fiber)
- Bounding particulate load (coatings, dust/dirt)
- Bounding sump pool chemistry (pH, boron concentration)
- Representative sump temperature cool-down profile
- Bounding approach velocity
- Bounding dissolved aluminum concentration as a function of ECCS mission time

The input parameters for the IPT are representative of the McGuire and Catawba post-LOCA sump conditions. Further details regarding these parameters can be found in the response to RAI #11 in Enclosure 1.

Available ECCS NPSH margin/head loss calculations have been documented for the clean strainer condition and the refined debris load condition in accordance with the approved methodology identified in NEI 04-07 and the NRC SER. The refined debris load head loss analysis does not yet incorporate chemical effects. Upon completion of the IPT documentation, a refined debris load head loss calculation will incorporate any added consequence of tested chemical effects and confirm the available ECCS NPSH margin. Duke expects to have this documentation and the McGuire Units 1 and 2 head loss calculations completed by April 30, 2008.

Request for Additional Information 9
Identify, if applicable, any plans to remove certain materials from the containment building and/or to make a change from the existing chemicals that buffer containment pool pH following a LOCA.

McGuire Response:
McGuire is an ice condenser plant, using sodium tetraborate in the ice condenser as a pH buffer. There are no plans to make any changes to the existing chemicals that buffer the McGuire containment pool pH following a LOCA.

Request for Additional Information 10
If bench-top testing is being used to inform plant specific head loss testing, indicate how the bench-top test parameters (e.g., buffering agent concentrations, pH, materials, etc.) compare to your plant conditions. Describe your plans for addressing uncertainties related to head loss from chemical effects including, but not limited to, use of chemical surrogates, scaling of sample size and test durations. Discuss how it will be determined that allowances made for chemical effects are conservative.

McGuire Response:
General Note:
In order to address specific ECCS head loss/NPSH issues, Duke designed a comprehensive Integrated Prototype Test (IPT) to assess chemical effects on the postulated post-LOCA debris bed at McGuire and Catawba. The design and set-up of the IPT is discussed in detail in the response to RAI #11 of Enclosure 1.

Bench-top tests (including laboratory tests and a 30-day Vertical Loop Test) were also performed as part of an aluminum release rate testing program, in order to provide insights for the Integrated Prototype Test parameters. The bench-top testing program that led to the development of the IPT is discussed here.

In February 2006, the Pressurized Water Reactor Owners Group (PWROG) issued WCAP-16530-NP, Revision 0, "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids in Support of GSI-191." This WCAP provided a chemical model that estimated the type and amounts of chemical precipitates that may be formed in a post-LOCA environment using plant specific containment materials inventories and environmental conditions (sump and atmosphere temperatures). Throughout 2006, Duke used this chemical model to ascertain the bounding amounts of any precipitates that may form in a thirty day period (the designed ECCS mission time).

Laboratory Aluminum Release Rate Testing

Duke performed aluminum corrosion and aluminum release rate testing internally to expand the PWROG test database. This testing has resulted in a better understanding of the materials' performance in the expected post-LOCA containment sump pool environments at the Duke plants (McGuire, Catawba, and Oconee Nuclear Stations).

WCAP-16530-NP, Revision 0 provided aluminum corrosion and release rate data over short time spans (1.5 hours) and a wide pH range. The additional corrosion and release rate tests performed by Duke Energy provided data over longer time spans and in environments more consistent with the post-LOCA sump pool chemistry at McGuire and Catawba.

For McGuire and Catawba, the aluminum release rate algorithm located in the WCAP-16530-NP spreadsheet was modified based on this testing. Compared to the WCAP algorithm, the Duke algorithm estimated lower aluminum releases at low pH and slightly higher aluminum releases at high pH. For the predicted post-LOCA environment for McGuire and Catawba, the Duke algorithm results in a conservatively increased mass of aluminum released when compared to the WCAP results.

Vertical Loop Testing

To better understand the sensitivity of the various input parameters used in the PWROG chemical model on the amount of possible chemical precipitates predicted and to gain insight into the behavior of various aluminum chemical species and their effect on pressure drop across a fiberglass insulation bed deposited on a representative strainer, Duke Energy constructed a Vertical Test Loop assembly and conducted a series of tests. The loop was completed in late 2006 and a total of fourteen tests with chemical additions were performed.

The Vertical Test Loop assembly which addressed both Catawba and McGuire was constructed using a flat plate strainer, and representative amounts of pre-treated fiber insulation were used to form a bed on the strainer. Tests were performed using predicted site specific chemistry and with additions of either sodium aluminum silicate particulate or soluble aluminum. Chemical loadings were based on model predictions using the PWROG chemical model provided by WCAP-16530-NP, modified with the Duke aluminum release rate algorithm, to estimate the amount of chemicals released and possible precipitates that might form subsequent to a LBLOCA. Use of this aluminum release rate algorithm was conservative, because it results in higher releases at the McGuire/Catawba estimated post-LOCA ECCS containment sump pool pH than those resulting from the WCAP algorithm with the same inputs. Flow velocities were conservatively based on Maximum Safeguards conditions. The Catawba maximum volume, Minimum Safeguards temperature profile scenario resulted in the highest aluminum release and was used as the bounding case for both McGuire and Catawba. As a result of the test loop volume to strainer area ratio being less than the plant ratio, the test loop concentrations of both silica and aluminum were considerably higher than actual concentrations predicted in the plant. This provided additional conservatism to the Vertical Test Loop results.

Request for Additional Information 11

Provide a detailed description of any testing that has been or will be performed as part of a plant-specific chemical effects assessment. Identify the vendor, if applicable, that will be performing the testing. Identify the environment (e.g., borated water at pH 9, deionized water, tap water) and test temperature for any plant-specific head loss or transport tests, Discuss how any differences between these test environments and your plant containment pool conditions could affect the behavior of chemical surrogates. Discuss the criteria that will be used to demonstrate that chemical surrogates produced for testing (e.g., head loss, flume) behave in a similar manner physically and chemically as in the ICET environment and plant containment pool environment.

McGuire Response:

General Note:

In order to address specific ECCS head loss/NPSH issues, Duke designed a comprehensive Integrated Prototype Test (IPT) to assess chemical effects on the postulated post-LOCA debris bed at McGuire and Catawba. Bench-top tests (including laboratory tests and a 30-day Vertical Loop Test) were also performed as part of an aluminum release rate testing program, in order to provide insights for the Integrated Prototype Test parameters. The bench-top testing program that led to the development of the IPT and to the refinement of its input parameters is discussed in the response to RAI #10 of Enclosure 1. The design and set-up of the IPT are discussed in detail here. IPT results will be address as stated in the response to RAI 12 of Enclosure 1.

Duke's strategy to evaluate chemical effects on the modified ECCS sump strainer head loss employs an Integrated Prototype Test (IPT) designed to simulate the predicted comprehensive challenge to the McGuire and Catawba ECCS Strainer modules (top-hats) in the post-LOCA containment pool. The IPT, performed by Wyle Laboratories at their Huntsville, Alabama facility in fall 2007, combined the physical and chemical characteristics expected in the post-accident environment just prior to ECCS sump pool recirculation, and then challenged a prototype strainer top-hat in the recirculating pool for the full 30-day ECCS mission time while representative chemical effects were introduced.

Integrated Prototype Test Setup

The test was conducted in a tank with a prototypical top-hat module mounted horizontally. To closely match the interaction of the top-hat with the surrounding strainer assemblies, vertical walls were placed in close proximity to the top-hat perforated plate on both sides. The module was also positioned so that the bottom edge of the lower base plate is in close proximity to the floor. The testing mimicked post-LOCA containment pool conditions, including a representative flow rate of borated water buffered with sodium tetraborate. A decreasing temperature profile was also followed. Debris sources predicted to arrive at the strainer, including NUKON® fiberglass, a failed coatings surrogate, and a dirt/dust surrogate, were added to the tank and allowed to accumulate on the top-hat module. In addition, an amount of NUKON® fiberglass insulation predicted to not physically transport to the top-hat was submerged in the system fluid so it is available to react chemically within the pool. To represent the sprayed and submerged condition of containment materials, a solution of aluminum nitrate is metered into the system over time according to a predicted concentration profile. The test continued for 30 days, while debris bed head loss, flow rate, temperature, and pool pH were monitored and recorded.

A 36-inch long prototype top-hat module was utilized in the IPT test loop. This length is representative of the population of top-hat modules available on the McGuire Unit 1 and 2 modified strainers (24 inch, 30 inch, 36 inch and 45 inch) and dimensionally similar to the population of top-hat modules available on the Catawba Unit 1 and 2 modified strainers. All other top-hat parameters (e.g., base plate, mesh size, diameter) on the test prototype module are identical to those installed in the McGuire and Catawba ECCS sumps, including the bypass eliminator feature.

Figure 11-1 below shows the physical IPT rig setup.

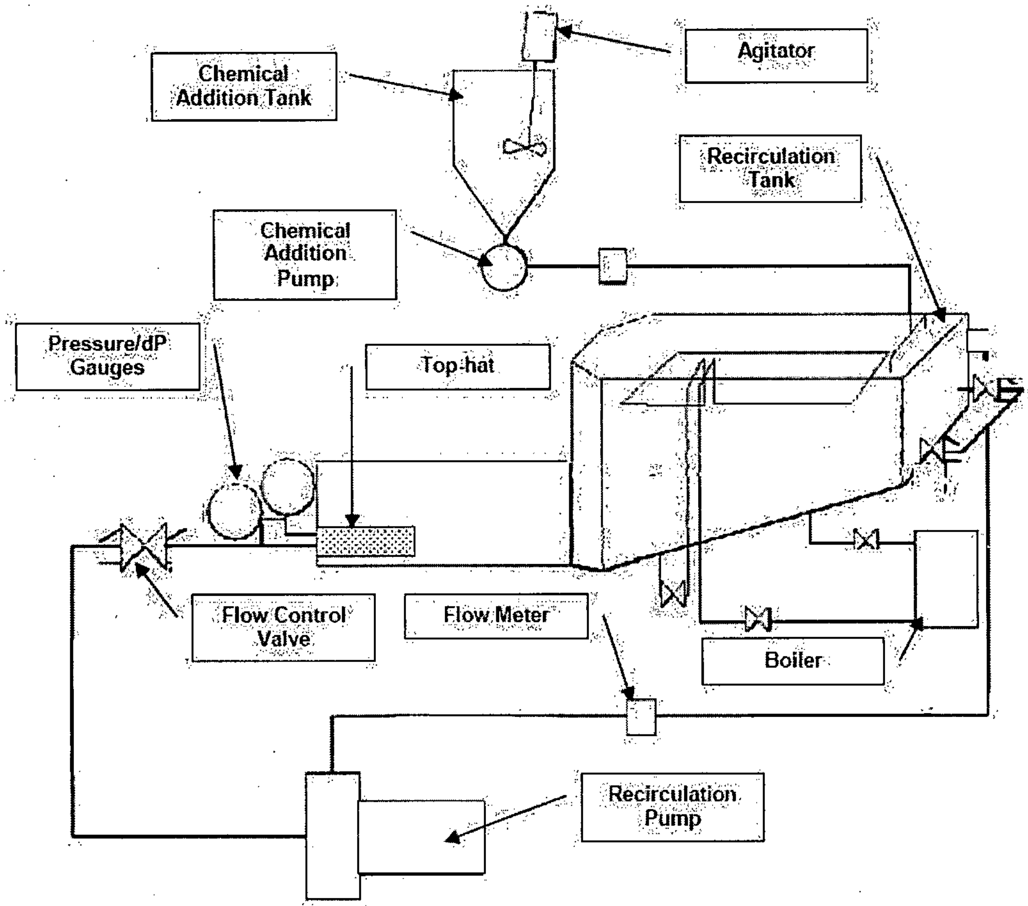


Figure 11-1

Integrated Prototype Test Setup

Test Environment

Representative Sump Pool Properties (boron, pH, buffering agent)

- Boron and pH
  The system boron concentration was initially 1730 ppm (+/- 300 ppm), added as boric acid to demineralized water. The boron concentration was approximately 2400 ppm (+/- 500 ppm) after pH adjustment with sodium tetraborate.

- Buffering Agent

  The pH was adjusted with sodium tetraborate to 7.9 (as measured at 25°C). The pH remained between 7.8 and 8.0 during the test period. Sodium hydroxide and nitric acid were used to maintain pH within the specification.

Representative sump pool temperature profile

In general, the Catawba post-LOCA minimum safeguards scenario has the highest temperatures, and the McGuire post-LOCA maximum safeguards scenario has the lowest temperatures. The highest temperature profile was simulated initially, and the lowest temperature profile simulated during the latter part of the test. This conservative approach ensures a bounding sump pool condition for potential chemical precipitates.

Figure 11-2 shows the expected temperature profiles for various post-LOCA scenarios at McGuire and Catawba during the ECCS mission time, and the representative IPT profile.

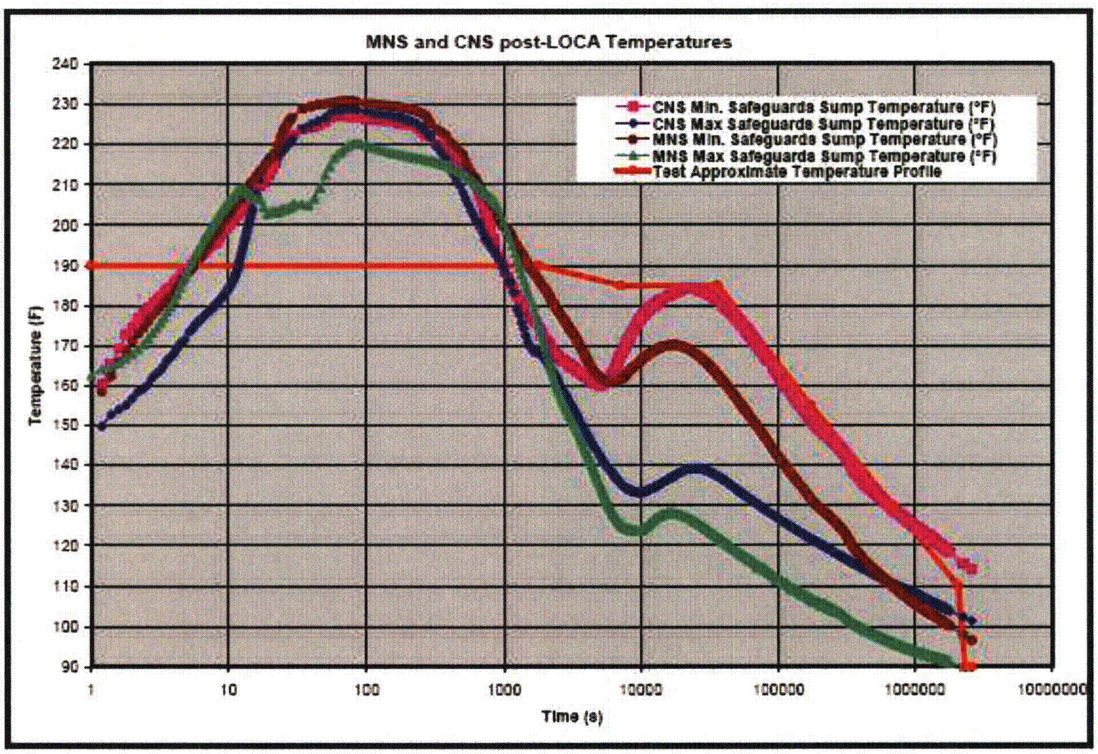


Figure 11-2

McGuire/Catawba Sump Pool Temperature Profiles

For the test, targeted pool temperature conditions (within +/- 5°F, with linear transitions),were as follows:

- The test was to start at 190°F and remain constant for 30 minutes.
- The system was to decline to 185°F at 2 hours and remain constant until 10 hours.
- The system was to decline to 155°F at 48 hours.
- The system was to decline to 130°F at 192 hours.
- The system was to decline to 110°F at 576 hours.
- The system was to decline gradually to 90°F at 648 hours and remain constant for the remainder of the test.

Representative approach velocity

An approach velocity of 0.0275 ft/sec was used, equating to a test flow rate through the top-hat module of approximately 114 gpm (+/- 5 gpm); this was above the expected maximum safeguards average approach velocity to the McGuire and Catawba ECCS sump strainers.

Conventional Debris

General Note:
The conventional debris quantities (fiber and coatings) used in the design of the IPT are refined quantities. Details regarding the refined quantities can be found in Sections 3(b) and 3(h) of Enclosure 2.

Representative debris loading (fiber)

The fiber debris load designed to challenge the top-hat in the IPT test loop reflected the postulated loading generated from a large break LOCA located on the Reactor Coolant System B Loop Hot Leg at McGuire. This bounds the postulated loading generated from the limiting large break LOCA located on the Reactor Coolant System B Loop Crossover Leg at Catawba. Nukon® fiber insulation was used to represent fiber insulation systems for the IPT. The fiber debris load thickness for the IPT was conservatively approximated at 1.75 inches. This value is representative of the expected post-LOCA conditions are McGuire and bounding for Catawba. Also, to be representative of the expected post-LOCA condition at each plant, the insulation was in a shredded form and baked to remove any organic binders.

In addition to the fiber debris load expected at the strainer top-hat, there was an additional amount of fibrous debris expected to transport to the containment sump pool and submerge, but not make it to the strainer modules. This additional fibrous debris was therefore available to react with the containment sump pool fluid but not collect on the strainer. The potential chemical interaction with this material was accommodated in the IPT via the immersion of more Nukon® fiber to the test pool in a proportioned amount appropriate to the refined debris analysis.

Representative particulate loading (dust, dirt, failed coatings)

The surrogate material for latent dirt and dust is a material blend of silica sand representative of PWR latent dirt/dust particles. The size distribution of the sand was prepared consistent with the latent dirt/dust distribution provided in the NRC SER of NEI 04-07.

The failed coatings debris surrogate material was selected based on chemical reactivity and a comparison of microscopic densities. Epoxy and alkyd coatings densities at plants range from 94 lb/ft^3 to 98 lb/ft^3 per NEI 04-07 guidance. The surrogate used for epoxy and alkyd coatings was silica flour, which has a material specific gravity of 2.65 (microscopic density of 165.4 lb/ft^3).

The critical parameter for selecting the surrogate material is the volume of the material in the debris mix. The particulate material occupies a certain volume in the fibrous debris space that results in increasing resistance to flow, and therefore higher head loss. The surrogate material volume was adjusted to match the volume of the failed coatings particulate when it is less dense than the surrogate. The particle size for all failed coatings (epoxy, alkyd, and inorganic zinc) is assumed to be 10 microns per NEI 04-07 guidance. The surrogate materials were a spherical particulate, where 99% is less than 45 microns in diameter and 69% is less than 10 microns in diameter.

Chemical debris addition (calcium, silica)/Injection of dissolved aluminum

Chemical debris in the post-LOCA environment for McGuire and Catawba will largely include dissolved aluminum and silica. While no calcium precipitates are predicted to form in the containment sump pool, calcium chloride is added to the IPT pool to achieve a representative I conditions. calcium concentration that mimics expected containment poo

- Calcium
  The IPT calcium concentrations simulate the highest estimated plant releases. Other particulate additions (fiberglass, surrogate debris materials, etc.) were taken into account to obtain a final solution calcium concentration of approximately 7-10 ppm.
- Silicon
  The scaled volume of non-transported NUKON® was submerged in the test pool fluid while preventing it from reaching the top-hat module. Dissolution of the submerged NUKON® by the pool chemistry provides the majority of

dissolved silicon as predicted by the WCAP methodology. Due to temperature limitations of the tank, the test was conducted at a lower temperature for the first hour. The silicon predicted by the WCAP methodology to be released in this period was added as sodium silicate. The dissolved aluminum and silicon may react with sodium from the pool buffering agent to form sodium aluminum silicate, a potential precipitate. The final total silicon concentration from all sources in the IPT pool was approximately 30 ppm to bound the highest predicted concentration in the post-LOCA containment sump pool.

- Dissolved Aluminum
  An aqueous solution of aluminum nitrate is metered into the system based on the aluminum release profile predicted by the WCAP-16530-NP model, assuming minimum safeguards and the McGuire (MNS) and Catawba (CNS) aluminum release rate algorithm determined from the Duke bench-top testing program. To the extent reasonable, a scaled Catawba minimum safeguards release rate for the IPT was simulated, since it is bounding for both plants. In addition, to demonstrate stability, the IPT includes a run period with no aluminum injection at the end of the test.

  Figure 11-3 shows the expected aluminum release rates at McGuire and Catawba for various post-accident scenarios during the ECCS mission time.

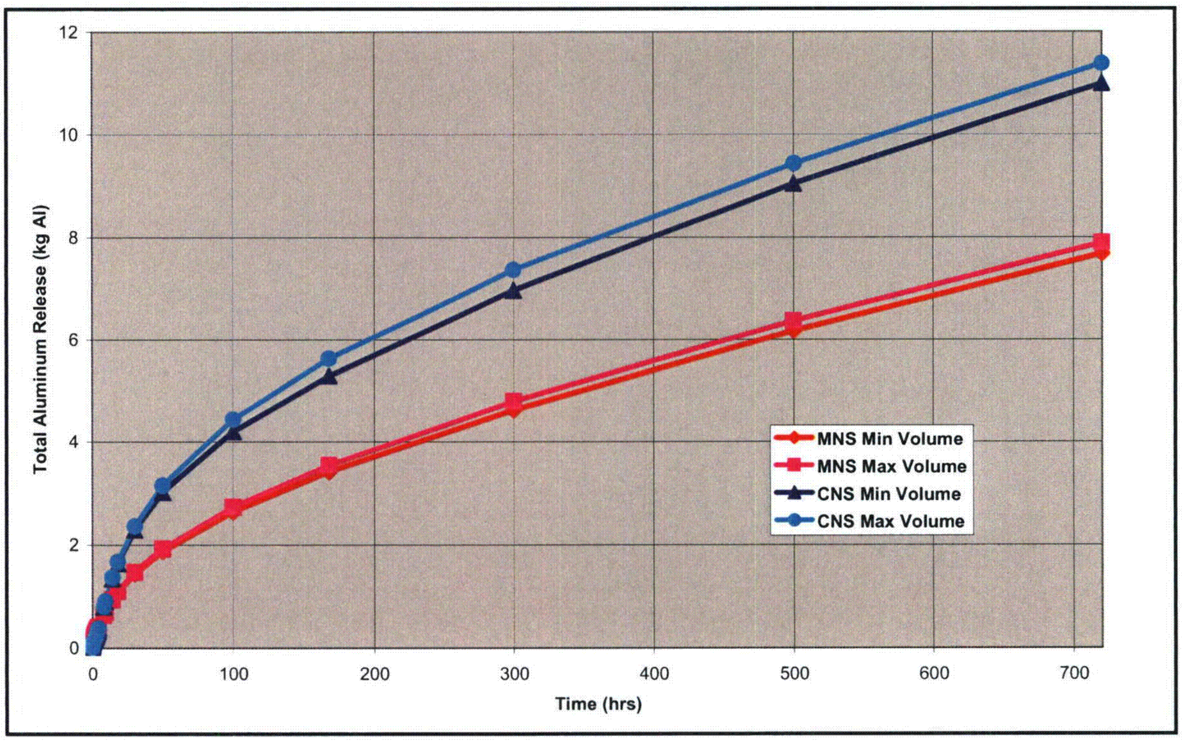


Figure 11-3

McGuire/Catawba Post-LOCA Aluminum Release Rates

For the IPT, the target aluminum injection profile was to follow the schedule shown in Table 11-1 below. The target quantities were to be achieved by slowly injecting the solution to minimize the local concentration at the injection location.

Table 11-1
Aluminum Injection Schedule

Start of Interval (hrs)	End of Interval (hrs)	Cumulative Volume of Aluminum Nitrate as 0.167% $Al(NO_3)_3 \cdot 9H_2O$ Solution (gal)	Rate of Addition (gph)
0	8	10.1	1.27
8	18	18.4	0.83
18	24	21.7	0.55
24	48	31.7	0.42
48	96	43.8	0.26
96	168	56.1	0.18
168	288	71.2	0.13
288	504	92.8	0.10
504	672	98.1	0.04

For reference, Table 11-2 shows the final estimated releases and concentrations for the McGuire and Catawba post-LOCA ECCS sump pool assuming minimum safeguards temperatures, the Duke aluminum release rate algorithm, estimated aluminum surface areas and wetted fiberglass volume estimates.

Table 11-2
McGuire and Catawba Final Estimated Releases and Concentrations

	CNS max. vol.	CNS min. vol.	MNS max. vol.	MNS min. vol.
Ca Release (kg)	14.72	14.72	14.72	14.72
Si Release (kg)	80.51	52.44	52.21	34.25
Al Release (kg)	11.38	10.99	7.89	7.68
Ca Concentration (ppm)	4.5	8.3	4.5	8.2
Si Concentration (ppm)	24.4	29.4	15.8	19.2
Al Concentration (ppm)	3.4	**6.2**	2.4	4.3
Al/Gross Screen area (g Al/ft^2)	**4.74**	4.58	4.64	4.52

Assumptions for this table:
Minimum volume = 1784857.2 kg water
Maximum volume = 3300017.2 kg water
CNS Final Gross Screen Area = 2400 ft^2
CNS Final Net Screen Area = 1772 ft^2
MNS Final Gross Screen Area = 1700 ft^2
MNS Final Net Screen Area = 1317 ft^2
CNS reduced wetted fiberglass estimate = 625 ft^3
MNS reduced wetted fiberglass estimate = 625 ft^3
CNS final submerged aluminum = 563.2 ft^2
CNS final sprayed aluminum = 140.1 ft^2
MNS final submerged aluminum = 530 ft^2
MNS final sprayed aluminum = 736 ft^2

<u>Request for Additional Information 12</u>
For your plant-specific environment, provide the maximum projected head loss resulting from chemical effects (a) within the first day following a LOCA, and (b) during the entire ECCS recirculation mission time. If the response to this question will be based on testing that is either planned or in progress, provide an estimated date for providing this information to the NRC.

<u>McGuire Response</u>:
The response to RAI #12 will be based on the results of the Integrated Prototype Test (IPT). Maximum projected head loss, limiting NPSH margins and all supporting information regarding refinements to the initial evaluations will be provided by April 30, 2008 as described in the December 28, 2007 extension request approval.

<u>Request for Additional Information 13</u>
Results from the ICET #1 environment and the ICET #5 environment showed chemical products appeared to form as the test solution cooled from the constant 140°F test temperature. Discuss how these results are being considered in your evaluation of chemical effects and downstream effects.

<u>McGuire Response:</u>
As described in the response to RAI #10 of Enclosure 1, aluminum solubility conditions were evaluated by Duke Energy via bench-top testing. As part of that evaluation, the final temperature during the 30-day Vertical Loop Test was less than the lowest predicted McGuire ECCS post-LOCA containment pool temperature at 30 days.

As described in the response to RAI #11 of Enclosure 1, these Vertical Loop Test evaluations were incorporated into the test plan for the Integrated Prototype Test (IPT) for chemical effects. The test plan simulated the full range of expected post-accident ECCS sump temperatures at McGuire. As in the Vertical Loop Test, the IPT final temperature was less than the lowest predicted ECCS sump temperature for McGuire at 30 days. To achieve this, the temperature of the IPT was reduced to 90°F during the latter part of the test. This test evaluated aluminum solubility, using specific chemistry and environmental parameters for McGuire Nuclear Station. The IPT results will be used to assess the total predicted post-LOCA head loss through the modified McGuire ECCS sump strainers, including chemical effects.

Downstream chemical effects are addressed in Section 3(o) of Enclosure 2.

<u>Request for Additional Information 25</u>
Describe how your coatings assessment was used to identify degraded qualified/acceptable coatings and determine the amount of debris that will result from these coatings. This should include how the assessment technique(s) demonstrates that qualified/acceptable coatings remain in compliance with plant licensing requirements for design-basis accident (DBA) performance. If current examination techniques cannot demonstrate the coatings' ability to meet plant licensing requirements for DBA performance, licensees should describe an augmented testing and inspection program that provides assurance that the qualified/acceptable coatings continue to meet DBA performance requirements. Alternately, assume all containment coatings fail and describe the potential for this debris to transport to the sump.

<u>McGuire Response:</u>
The comprehensive Duke Energy Corporation Containment Coatings Assessment Program in effect at McGuire Nuclear Station is used to identify degraded qualified/acceptable coatings and determine the amount of debris that will result from these coatings. This program also ensures that qualified/acceptable coatings remain in compliance with plant licensing requirements for design-basis accident (DBA) performance. If, after identification, degraded qualified/acceptable coatings will be left in place during plant operation, the degraded qualified/acceptable coatings are assumed to fail and to be available for transport to the ECCS sump.

Insights on the Containment Coatings Assessment Program
As originally discussed in Duke Energy Corporation's McGuire Nuclear Station response dated November 11, 1998 to Nuclear regulatory Commission (NRC) Generic Letter 98-04, "Potential for Degradation of the Emergency Core Cooling System and the Containment Spray System After a Loss-of-Coolant Accident Because of Construction and Protective Coating Deficiencies and Foreign Material in Containment", a comprehensive program is in place at McGuire Nuclear Station for assessing and documenting the condition of qualified/acceptable coatings in primary containment. This program generates data which is used to schedule qualified/acceptable coating maintenance to ensure that qualified/acceptable primary containment coatings will not fail (detach) during normal and accident conditions and thus not contribute to the Emergency Core Cooling System (ECCS) debris source term.

The Containment Coating Assessment Program is controlled through a Nuclear Generation Department level document. This guidance document specifies details for assessing and developing the condition of all coatings, including qualified/acceptable coatings, located in the McGuire Nuclear Station primary containments. The requirements of the Containment Coating Assessment program are procedurally implemented at McGuire.

A primary containment coatings condition assessment is conducted during each refueling outage. Visual inspections are conducted and documented by ANSI N45.2.6 Level II personnel and/or personnel who have demonstrated overall technical knowledge of coatings. The resultant data is reviewed by the site Coating Specialist and is used to facilitate proper planning and prioritization of coatings maintenance as needed to maintain the integrity of qualified/acceptable primary containment coating systems.

The guidance provided in ASTM D5163, "Standard Guide for Establishing Procedures to Monitor the Performance of Coating Service Level I Coating Systems in an Operating Nuclear Power Plant," and EPRI Report 109937 "Guideline on Nuclear Safety-Related Coatings: Revision 1" (November 2001) is incorporated in the McGuire Nuclear Station primary containment coatings condition assessment program. The primary containment coating condition assessment protocol consists of a visual inspection of all readily accessible coated areas by qualified personnel. The use of visual inspection by qualified personnel for containment coating assessment has been validated by the recently-issued EPRI Report 1014883 "Plant Support Engineering: Adhesion Testing of Nuclear Coating Service Level 1 Coatings" (August 2007).

When degraded coatings are visually identified, the affected areas are documented in accordance with plant procedures. Additional nondestructive and/or destructive examinations are conducted as appropriate to define the extent of the degraded coatings and to enable disposition of the coating deficiency. The guidance contained in EPRI Report 109937 is used as appropriate to disposition areas of degraded coatings when discovered, including:

1. performance of additional in situ and/or laboratory testing of degraded coatings,
2. removal and replacement of degraded coatings,
3. repairing degraded coatings,
4. mitigation of accident consequences related to failure of degraded coatings,
5. leaving in place based on evaluation of effects of failure (detachment) of the degraded coating on ECCS system performance, and/or,
6. upgrading of indeterminate coatings.

The following industry technical documents are used as appropriate in determining the physical characteristics of debris resulting from any degraded coatings identified during primary containment coatings condition assessments:

1. "Analysis of Pressurized Water Reactor Unqualified Original Equipment Manufacturer Coatings", EPRI Report 1009750, March 2005.

2. "Design Basis Accident Testing of Pressurized Water Reactor Unqualified Original Equipment Manufacturer Coatings", EPRI Report 1011753, September 2005.

3. Keeler & Long Report No. 06-0413, "Design Basis Accident Testing of Coating Samples from Unit 1 Containment, TXU Comanche Peak SES."

Request for Additional Information 30

The NRC staff's safety evaluation (SE) addresses two distinct scenarios for formation of a fiber bed on the sump screen surface. For a thin bed case, the SE states that all coatings debris should be treated as particulate and assumes 100% transport to the sump screen. For the case in which no thin bed is formed, the staff's SE states that the coatings debris should be sized based on plant-specific analyses for debris generated from within the ZOI and from outside the ZOI, or that a default chip size equivalent to the area of the sump screen openings should be used (Section 3.4.3.6). Describe how your coatings debris characteristics are modeled to account for your plant-specific fiber bed (i.e. thin bed or no thin bed). If your analysis considers both a thin bed and a non-thin bed case, discuss the coatings debris characteristics assumed for each case. If your analysis deviates from the coatings debris characteristics described in the staff-approved methodology, provide justification to support your assumptions.

McGuire Response:

The modified McGuire ECCS sump strainer utilizes an array of strainer modules (top-hats) that do not exhibit thin-bed formation.

The coatings debris analysis for McGuire followed the staff-approved methodology for the non-thin bed case. The exception is that a ZOI of 5D is assumed in lieu of the 10D ZOI prescribed in the SER, based on the results of specific testing performed under WCAP-16568-P.

For post-LOCA debris generation analyses, qualified coatings within the 5D ZOI at the limiting High Energy Line Break location were postulated to fail, as well as all unqualified coatings within the containment building. Qualified coatings within the 5D ZOI and all unqualified coatings are assumed to fail as 10 micron spheres, 100% of which transport to the ECCS sump.

A detailed discussion of coatings debris characteristics and analytical assumptions can be found in Section 3(h) of Enclosure 2.

Request for Additional Information 31
Was/will "leak before break" be used to analyze the potential jet impingement loads on the new ECCS sump screen?

McGuire Response:
The application of "leak before break" (LBB) technology was approved for McGuire Units 1 and 2 primary coolant loops by NRC letter dated May 8, 1986. As described in Section 3.6.2.1.1 of the McGuire UFSAR, LBB was used to eliminate breaks postulated in the original design of the Reactor Coolant System primary loop piping. Postulated high energy pipe breaks which could potentially interact with the modified ECCS containment sump strainer were evaluated in accordance with McGuire's current licensing basis as follows:

a. High Energy Pipe Rupture composite drawings were reviewed to identify any postulated breaks in close proximity to the modified ECCS sump strainer assembly and associated enclosure.
b. Postulated breaks were evaluated to determine if interaction existed with the modified ECCS containment sump strainer and associated enclosure by being within the target zone of pipe whip or jet impingement.

Per the above methodology, one interaction per Unit at McGuire was identified based upon the new locations of the modified strainer assemblies.

Regulatory commitments were made to install pipe rupture restraints/jet barriers on the Residual Heat Removal System of each Unit to address this interaction. The rupture restraint/jet barrier has been installed on Unit 1 (1EOC18 outage, spring 2007), and the rupture restraint/jet barrier will be installed on Unit 2 prior to beginning cycle 19 (2EOC18 outage, spring 2008).

LBB methodology was only used for evaluation of pipe whip, jet impingement and dynamic loads on the modified McGuire ECCS strainer. LBB methodology was not used in the GSI-191 determination of debris generated as a result of a LOCA. A fully offset, double-ended guillotine break of the primary coolant loop was used for debris source term. The break location chosen was bounding for debris source term. Further details regarding the debris generation evaluation are located in Section 3(b) of Enclosure 2.

Request for Additional Information 32

You indicated that you would be evaluating downstream effects in accordance with WCAP 16406-P. The NRC is currently involved in discussions with the Westinghouse Owner's Group (WOG) to address questions/concerns regarding this WCAP on a generic basis, and some of these discussions may resolve issues related to your particular station. The following issues have the potential for generic resolution; however, if a generic resolution cannot be obtained, plant-specific resolution will be required. As such, formal RAIs will not be issued on these topics at this time, but may be needed in the future. It is expected that your final evaluation response will specifically address those portions of the WCAP used, their applicability, and exceptions taken to the WCAP. For your information, topics under ongoing discussion include:

a. **Wear rates of pump-wetted materials and the effect of wear on component operation**
b. **Settling of debris in low flow areas downstream of the strainer or credit for filtering leading to a change in fluid composition**
c. **Volume of debris injected into the reactor vessel and core region**
d. **Debris types and properties**
e. **Contribution of in-vessel velocity profile to the formation of a debris bed or clog**
f. **Fluid and metal component temperature impact**
g. **Gravitational and temperature gradients**
h. **Debris and boron precipitation effects**
i. **ECCS injection paths**
j. **Core bypass design features**
k. **Radiation and chemical considerations**
l. **Debris adhesion to solid surfaces**
m. **Thermodynamic properties of coolant**

McGuire Response:

The downstream effects issues identified in this 2006 RAI are addressed via the NRC's "Revised Content Guide for Generic Letter 2004-02 Supplemental Responses", dated November 2007. McGuire responses to the related Content Guide issues are located in Section 3(m), Section 3(n), and Section 3(o) of Enclosure 2.

Request for Additional Information 33

Your response to GL 2004-02 question (d)(viii) indicated that an active strainer design will not be used, but does not mention any consideration of any other active approaches (i.e., backflushing). Was an active approach considered as a potential strategy or backup for addressing any issues?

McGuire Response:

The use of backflushing (or other active mitigative strategies) was not considered feasible for the McGuire modified ECCS strainer design.

Request for Additional Information 34

McGuire stated that the containment walkdown for Unit 1 will be completed in accordance with Nuclear Energy Institute (NEI) 02-01 during the fall 2005 outage. Please discuss the plans to incorporate the results of this future containment walkdown into the sump design analyses.

McGuire Response:

The McGuire ECCS sump strainer GSI-191 Baseline Analysis used the Unit 2 containment walkdown results, since at the time the Unit 1 containment walkdowns had not been completed. It was assumed that the Unit 2 debris source terms would bound the Unit 1 debris source terms for the purposes of the initial strainer sizing calculations.

The McGuire Unit 1 containment walkdown was completed as scheduled during the fall 2005 outage in accordance with NEI 02-01 requirements. The walkdown findings confirmed that the debris sources identified by the McGuire Unit 2 containment walkdown bound the Unit 1 debris sources with two exceptions:

a. The insulation on the Unit 1 reactor coolant pumps is Nukon® (a fibrous insulation), while the Unit 2 reactor coolant pumps have the original reflective metal insulation (RMI) installed.

The debris source term introduced by the additional Nukon® insulation on the Unit 1 reactor coolant pumps was incorporated into the McGuire Unit 1 ECCS sump strainer design analysis.

b. The latent debris load (dust, dirt, and lint) in Unit 1 was estimated to be higher than that estimated in Unit 2, based on specific sampling.

The increased amount of latent debris (dust, dirt, and lint) estimated for McGuire Unit 1 is accommodated by the conservative initial source term assumption of 200 lbm in the ECCS sump strainer design analysis. Both the Unit 1 and the Unit 2 latent debris containment walkdown estimates for latent debris are well below this assumed value.

The modified ECCS sump strainer design for McGuire Units 1 and 2 incorporated these values, as applicable, which were refined following the Unit 1 walkdown.

<u>Request for Additional Information 35</u>

You stated that Microtherm® insulation (currently installed on portions of the reactor vessel heads) will be replaced, and that this replacement will reduce the postulated post-accident debris loading on the sump strainer. Please discuss the insulation material that will replace the Microtherm® insulation, including debris generation and characteristics parameters. Has the new insulation been evaluated in the debris generation, transport, head loss analyses and other sump design analyses?

<u>McGuire Response:</u>

Microtherm® insulation previously installed on portions of the McGuire Unit 1 and Unit 2 reactor vessel heads was removed and replaced with Reflective Metal Insulation (RMI). The reactor vessel head is not in the area of the limiting break. In addition, debris transport calculations that have been completed for McGuire Units 1 and 2 show that RMI (for the limiting break location) will not transport to the containment sump. Debris transport for the limiting break is described in detail in 3(e), Table 3E6-1 of Enclosure 2.

<u>Request for Additional Information 36</u>

You did not provide information on the details of the break selection, ZOI and debris characteristics evaluations other than to state that the Nuclear Energy Institute (NEI) and SE methodology were applied. Please provide a description of the methodologies applied in these evaluations and include a discussion of the technical justification for deviations from the SE-approved methodology.

<u>McGuire Response:</u>

A detailed discussion of the methodologies for Break Selection, Zone of Influence (ZOI), and Debris Characteristics evaluations, as they apply to the modified McGuire ECCS strainer design, are located in Enclosure 2 of this submittal. The specific sections are identified below.

Break Selection Evaluation Methodology

- Enclosure 2, Section 3(a)

Zone of Influence (ZOI) Evaluation Methodologies

- Enclosure 2, Section 3(b) for insulation
- Enclosure 2, Section 3(h) for coatings

Debris Characteristics Evaluation Methodology

- Enclosure 2, Section 3(c) for fiber and particulate debris
- Enclosure 2, Section 3(d) for latent debris

Request for Additional Information 37
Has debris settling upstream of the sump strainer (i.e., the near-field effect) been credited or will it be credited in testing used to support the sizing or analytical design basis of the proposed replacement strainers? In the case that settling was credited for either of these purposes, estimate the fraction of debris that settled and describe the analyses that were performed to correlate the scaled flow conditions and any surrogate debris in the test flume with the actual flow conditions and debris types in the plant's containment pool.

McGuire Response:
Upstream debris settling due to the "near-field effect" is not credited in the head loss testing or in the analytical design basis for the sizing of the McGuire modified ECCS sump strainers. The debris transport calculation (and so the strainer design basis) assumes that 100% of the particulate debris (failed coatings) and latent debris (dust, dirt, and lint) will challenge the strainer after the limiting break. The debris transport fractions for destroyed insulation were determined based on a computational fluid dynamics model.

<u>Request for Additional Information 38</u>

Are there any vents or other penetrations through the strainer control surfaces which connect the volume internal to the strainer to the containment atmosphere above the containment minimum water level? In this case, dependent upon the containment pool height and strainer and sump geometries, the presence of the vent line or penetration could prevent a water seal over the entire strainer surface from ever forming; or else this seal could be lost once the head loss across the debris bed exceeds a certain criterion, such as the submergence depth of the vent line or penetration. According to Appendix A to Regulatory Guide 1.82, Revision 3, without a water seal across the entire strainer surface, the strainer should not be considered to be "fully submerged," Therefore, if applicable, explain what sump strainer failure criteria are being applied for the "vented sump" scenario described above.

<u>McGuire Response:</u>

There are no vents or other penetrations through the modified McGuire ECCS strainer connecting the interior of the strainer to the containment atmosphere above the containment minimum water level. The McGuire strainer is designed to be fully submerged, and as discussed in the response to RAI #41 of Enclosure 1, is fully submerged even in the bounding SBLOCA scenario.

<u>Request for Additional Information 39</u>

What is the minimum strainer submergence during the postulated LOCA? At the time that the re-circulation starts, most of the strainer surface is expected to be clean, and the strainer surface close to the pump suction line may experience higher fluid flow than the rest of the strainer. Has any analysis been done to evaluate the possibility of vortex formation close to the pump suction line and possible air ingestion into the ECCS pumps? In addition, has any analysis or test been performed to evaluate the possible accumulation of buoyant debris on top of the strainer, which may cause the formation of an air flow path directly through the strainer surface and reduce the effectiveness of the strainer?

<u>McGuire Response:</u>

Minimum Submergence

As discussed in the response to RAI #41 of Enclosure 1, the minimum McGuire ECCS sump strainer submergence during the limiting SBLOCA containment sump pool inventory scenario is at least 2 inches.

Vortex Formation Evaluation

With an initially clean ECCS sump strainer surface, approach velocities for the top-hat modules closest to the pump suction line are expected to be higher than the

McGuire predicted nominal approach velocity by approximately a factor of two. A full-scale 36 inch long top-hat module was used to test for vortex formation at various approach velocities, while conservatively maintaining the water level only 3 inches above the top surface of the top-hat perforated plate (the expected minimum water level above this surface is about 4 inches). The approach velocity through the clean module was increased until an air-entraining vortex was formed, and then the vortex suppressor grating was placed into a position above the top-hat module. The air-entraining vortices that formed at higher approach velocities were eliminated by the vortex suppressor grating in each case, and only minor surface dimpling remained. No vortices were observed at lower approach velocities. Vortex suppression testing is discussed in detail in Section 3(f) of Enclosure 2, and demonstrates that the McGuire ECCS sump strainers are not susceptible to air-entraining vortex formation.

Accumulated Buoyant Debris
The McGuire ECCS strainer is designed to be fully submerged and un-vented, as identified in the response to RAI #38 of Enclosure 1. The only portion of the predicted post-LOCA debris load that could potentially remain buoyant is the low density fiberglass insulation (LDFG), and industry testing has shown that LDFG insulation debris becomes saturated and sinks very quickly in hot water, while intact jacket-covered "pillows" can remain afloat. In the unlikely event that some large intact pieces survive the blowdown and transport to the pipechase through the crane wall penetrations, the fully submerged Pipechase Vortex Suppression Rack will be sufficient to preclude any opportunity for an artificial vent to form between the top-hats and the surface of the water.

Request for Additional Information 40

Please provide a detailed description of the analyses/testing performed to evaluate the new strainer head loss.

McGuire Response:
Detailed discussion regarding the analyses/testing performed to evaluate the modified McGuire ECCS strainer head loss is located in Section 3(f) and Section 3(o) of Enclosure 2.

Request for Additional Information 41
Describe, in detail, the analysis performed to determine the minimum water level, and explain how the water source from the ice condenser is determined.

McGuire Response:
The limiting analytical case for minimum ECCS sump level at McGuire can be characterized as a small break LOCA (SBLOCA) during which Containment Spray does not actuate and there is no water source contribution from ice melt. In addition, this containment analysis conservatively accounts for potentially diverted ECCS injection inventory.

The analysis assumes a small break of indeterminate size which fills up the incore instrumentation room (located below the reactor vessel), but has insufficient energy to cause the Containment Spray system to actuate. No ice melt is credited in this analysis. Credited water for this specific accident includes the Technical Specification minimum inventory from the Refueling Water Storage Tank (FWST), and the FWST low-low level setpoint is conservatively error-adjusted upward to minimize the usable FWST volume. The following ECCS sump inventory penalties (lost water sources) are applied in this analysis:

- Reactor Coolant System shrinkage
- Incore instrumentation room diversion
- Volume Control Tank diversion
- Pressurizer Relief Tank diversion
- Lower containment ventilation system condensation diversion (loss of lower containment condensate through drain pans and drain lines)

For this SBLOCA scenario, a sump pool level of 36 inches above the sump floor is calculated. This corresponds to a water level which is at least 2 inches above the vortex suppressor of the modified McGuire sump strainers. The ECCS sump level switch set point is selected such that the level alarm will indicate sufficient level for ECCS pump alignment to the sump under the limiting case. This is the minimum calculated water level for the bounding SBLOCA scenario, and confirms that the modified ECCS sump structure at McGuire is submerged when the FWST reaches the low-low level setpoint.

For SBLOCA scenarios which automatically actuate the Containment Spray system, sump strainer submergence is also confirmed. Additional inventory penalties related to the use of containment spray are applied to account for holdup of water within upper containment (beneath the elevation of the refueling canal drains, within

Containment Spray piping, film layers on walls, etc.). Since any break size which would cause the Containment Spray system to automatically actuate (at a containment pressure of 3 psig) would also lead to the opening of the Ice Condenser Inlet Doors, an ice melt contribution is calculated for those events. Additionally, the interaction of the sump level switches and the variation of the incore instrumentation room volume as a function of time are considered.

Request for Additional Information 42

Duke's September 2005 GL response stated that the design of the modified containment sump would accommodate the effects of debris loading as determined by the baseline evaluation, which was under review by Duke, and the ongoing refined evaluation for Catawba and that the evaluations use the guidance of NEI 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology, Revision 0," dated December 2004. Please supplement your GL response after completing the review.

McGuire Response:

A supplement to McGuire's GL 2004-02 response based on the NRC's guidance of November 21, 2007 is included as Enclosure 2 of this submittal. McGuire will further supplement its response by April 30, 2008 as committed in its November 6, 2007 letter.

Enclosure 2

Generic Letter 2004-02 Supplemental Responses

Enclosure 2
Information Addressing Issues Identified in Staff Content Guide for Generic Letter 2004-02 Supplemental Responses
McGuire Nuclear Station

Specific Guidance for Review Areas

1. Overall Compliance:
Provide information requested in GL 2004-02 Requested Information Item 2(a) regarding compliance with regulations.

GL 2004-02 Requested Information Item 2(a)
Confirmation that the ECCS and CSS recirculation functions under debris loading conditions are or will be in compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of this GL. This submittal should address the configuration of the plant that will exist once all modifications required for regulatory compliance have been made and this licensing basis has been updated to reflect the results of the analysis described above.

McGuire Response
GL 2004-02 Requested Information Item 2(a) requests confirmation of three related items. The first item is confirmation that the ECCS and CSS recirculation functions under debris loaded conditions are in compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of GL2004-02:

> The status of McGuire Nuclear Station's compliance with the regulatory requirements includes:
>
> McGuire Nuclear Station requested in a letter dated February 9, 2007, an extension to complete the Unit 2 ECCS sump strainer. McGuire requested an extension to the spring 2008 refueling outage to complete installation of the Unit 2 ECCS Sump strainer. This extension was approved by the US NRC in a letter dated December 19, 2007.
>
> McGuire Nuclear Station, Units 1 and 2 requested in a letter dated November 6, 2007, an extension to complete the chemical effects testing and update the associated reports and design documents. Any additional or revised information resulting from the Integrated Performance Test (chemical effects testing) will be provided as an amended response by April 30, 2008. The extension was approved by the staff in a letter dated December 28, 2007.
>
> McGuire Nuclear Station anticipates being in full compliance with the applicable regulatory requirements for long term core cooling, containment heat removal, and containment atmospheric cleanup by the requested extension dates. The April 30, 2008 amended response will include this confirmation.

The second confirmation item is to describe the configuration of the plant once all modifications are made:

McGuire Nuclear Station will have installed modified ECCS strainers in each Unit to address issues identified in GL 2004-02. The modified ECCS sump strainers will have increased the surface area from the original 135 square feet, to approximately 1700 square feet. The strainer hole size is reduced from 0.206 inch (original) to less than 0.094 inch nominal (new strainer). The McGuire ECCS sump design is described in detail in the March 8, 2007 License Amendment Request.

McGuire Nuclear Station has removed the Microtherm insulation, previously installed on the reactor vessel head on each Unit. The insulation was replaced with metal reflective insulation (RMI).

The third confirmation item is to describe the licensing basis of the plant once all modifications are made:

The status of the licensing basis updates includes:

A license amendment request was submitted by Duke on March 8, 2007 and supplemented March 27, April 13, and May 3 2007, to update the licensing basis of McGuire Nuclear Station relative to the modified ECCS strainer configuration. The purpose of this license amendment request was to revise the licensing commitments to Regulatory Guide 1.82, and revise Technical Specification Surveillance Requirement 3.5.2.8. This license amendment request was approved by amendments 240 (Unit 1) and 222 (Unit 2).

UFSAR changes will be made to update the licensing basis for other aspects of GL 2004-02 to describe the revised debris loaded ECCS sump strainer license basis, including:

- Break Selection
- Debris Generation
- Latent Debris
- Debris Transport
- Head Loss
- Additional Design Considerations

The UFSAR is submitted periodically to the USNRC. McGuire Nuclear Station provides this required update 6 months after each Unit 2 refueling outage. Unit 2 has a Spring 2008 refueling outage where the sump strainer installation will be completed. Therefore, the update including these changes will be submitted by fall 2008.

2. General Description of and Schedule for Corrective Actions:
Provide a general description of actions taken or planned, and dates for each. For actions planned beyond December 31, 2007, reference approved extension requests or explain how regulatory requirements will be met as per Requested Information Item 2(b). (Note: All requests for extension should be submitted to the NRC as soon as the need becomes clear, preferably not later than October 1, 2007.)

McGuire Response
McGuire Nuclear Station has used the guidance of NEI 04-07 to address ECCS sump performance. The analysis results required modifications to the ECCS sump strainers. The Unit 1 modification is complete, and the Unit 2 modification will be complete in the Spring 2008.

The following major activities have been completed in support of GL 2004-02:

- Baseline evaluation, performed by Enercon Services, Inc.
- Refined evaluation using the guidance of NEI 04-07, completed by Enercon Services, Inc.
- Downstream effects evaluation using the WCAP-16406-P, Rev. 0 methodology.
- Containment walkdowns using the guidance of NEI 02-01, "Condition Assessment Guidelines: Debris Sources Inside PWR Containments"
- The modification process and the plant labeling process have been enhanced relative to GL 2004-02 controls.
- Replacement of the Microtherm® insulation, previously installed on portions of the reactor vessel heads, with RMI.
- Installation of a new ECCS sump strainer in Unit 1 (~1700 sq ft).
- Installation of a new ECCS sump strainer in Unit 2 (phase I, ~1000 sq ft)
- Completion of the Integrated Prototype Test (Chemical Effects test)

The McGuire Unit 2 ECCS Sump strainer will be completed in the Spring 2008 refueling outage. The only significant activity remaining is completion of the analysis /report for the Integrated Prototype Test (chemical effects test) and incorporation of the results into the ECCS system NPSH calculations. Any additional or revised information resulting from the Integrated Performance Test (chemical effects testing) will be provided as an amended response by April 30, 2008.

As requested in the staff's extension approval letter dated December 28, 2007 Duke will provide additional information related to the NRC staff-requested evaluation of WCAP-16406, Revision 1 dated August 2007 in the April 30, 2008 submittal.

3(a) Break Selection
The objective of the break selection process is to identify the break size and location that present the greatest challenge to post-accident sump performance.

3(a)(1) Describe and provide the basis for the break selection criteria used in the evaluation.

McGuire Response:
Break locations were selected for the breaks that produce the maximum amount of debris and also the worst combination of debris mixes with the possibility of being transported to the ECCS sump strainer.

Additionally, breaks that might cause a "thin-bed" effect (i.e., a high volume of particulate debris on a thin fiber bed) were given consideration since these also have the potential to significantly impair sump strainer performance. The following break locations were analyzed for McGuire Units 1 and 2:

- Break 1: Locations in the Reactor Coolant System (RCS) with the largest potential for debris generation.
- Break 2: Locations with two or more different types of debris.
- Break 3: Locations with the most direct path to the sump.
- Break 4: Locations with the largest potential particulate to insulation ratio.
- Break 5: Locations that would generate debris that could potentially form a thin-bed.

Insights in the McGuire break selection process were gained from the NRC SER of NEI 04-07. The SER advocates break selection at 5 ft intervals along a pipe in question but clarifies that "the concept of equal increments is only a reminder to be systematic and thorough." It further qualifies that recommendation by noting that a more discrete approach driven by the comparison of debris source term and transport potential can be effective at placing postulated breaks.

The key difference between many breaks (especially large breaks) will not be the exact location along the pipe, but rather the envelope of containment material targets affected. A 17D ZOI for the Nukon® insulation (jacketed and unjacketed) used on RCS piping and components at McGuire is equivalent to a sphere with an approximate 40 ft radius, depending upon the size of the particular pipe break. A spherical ZOI of this size is bounded by structural barriers surrounding the RCS such as the reactor cavity, the crane wall, and the operating floor slabs. Also, due to the size of this ZOI, the specific location along a particular pipe has little if any impact on the amount of debris generated. Further, a reasonable determination of the most limiting location can be made by inspection of plant equipment drawings. Specific break locations can be selected by plotting the ZOI along the RCS piping to maximize major targets that fall within the perimeter of the ZOI sphere.

Following initial break selection as described above which was used to design the modified sump strainers, refinements in the break selection criteria were used to develop sump strainer testing parameters. A refined fiber insulation ZOI methodology defined by WCAP-16710-P is incorporated into the Integrated Prototype Test for chemical effects, described in the response to RAI #11 of Enclosure 1. The methodology provides for a 7D ZOI for jacketed fiber insulation in the break selection process. Review of the break locations evaluated using the 17D ZOI for fiber insulation show that the original limiting break for debris generation remains bounding for McGuire Units 1 and 2 when the 7D ZOI is applied to jacketed fiber insulation.

This refinement is discussed in further detail in Section 3(b) of Enclosure 2.

3(a)(2) State whether secondary line breaks were considered in the evaluation (e.g., main steam and feedwater lines) and briefly explain why or why not.

<u>McGuire Response:</u>
Secondary line breaks were not considered in the evaluation of debris generation. The secondary side breaks do not introduce a type of debris to the ECCS sump pool different than the primary side breaks. For debris generation, the smaller secondary side breaks inside the crane wall are bounded by the primary side breaks, and the larger primary side breaks result in more fibrous insulation debris and RMI debris.

Secondary side breaks were therefore not considered in the evaluation of debris generation, since the primary side breaks are bounding.

3(a)(3) Discuss the basis for reaching the conclusion that the break size(s) and locations chosen present the greatest challenge to post-accident sump performance.

<u>McGuire Response:</u>
As identified in the response to RAI #1 of Enclosure 1, at McGuire the limiting break for debris generation is the RCS Hot Leg, Loop B. This limiting break is a double-ended guillotine break (DEGB) of a primary loop, located nearest to the ECCS sump and the ECCS sump strainer. This break generates a high quantity of fiber and causes the transportation of the highest amount of fiber to the strainer.

3(b) Debris Generation / Zone of Influence (ZOI) (excluding coatings)
The objective of the debris generation / ZOI process is to determine, for each postulated break location: (1) the zone within which the break jet forces would be sufficient to damage materials and create debris; and (2) the amount of debris generated by the break jet forces.

General McGuire Response Note:
As identified by the NRC Content Guide, the responses provided below relate to debris generation/ZOI of fiber insulation and RMI at McGuire, excluding coatings. The debris generation/ZOI information relating to coatings inside containment is located in Section 3(h) of Enclosure 2. Debris generation information relating to latent debris inside containment is located in Section 3(d) of Enclosure 2.

3(b)(1) Describe the methodology used to determine the ZOIs for generating debris. Identify which debris analyses used approved methodology default values. For debris with ZOIs not defined in the guidance report (GR) / safety evaluation (SE), or if using other than default values, discuss method(s) used to determine ZOI and the basis for each.

McGuire Response:
For the initial evaluation of the generation of insulation debris, the ZOIs assumed were consistent with the default values specified in the NEI 04-07 guidance, including the SER. The methodology used in the initial GSI-191 debris generation evaluation for determining the break ZOIs at McGuire considered the double-ended guillotine break of the largest RCS piping. A spherical zone of influence centered at the break location is used, consistent with NEI 04-07 (and the companion SER) guidance. This initial evaluation provided an ECCS sump strainer area for the modified strainer design at McGuire. The sump strainer was subsequently increased again in the final design to provide further strainer margin.

A refined fiber insulation ZOI for jacketed insulation, using the results of specific jet impingement testing reported in WCAP-16710-P, was utilized as an input to the Integrated Prototype Test (IPT) for chemical effects described in detail in the response to RAI #11 of Enclosure 1. This is the only deviation from the SER approved methodology for insulation debris generation. A discussion of the application of this WCAP can be found in the response to item 3(b)(3), below.

3(b)(2) Provide destruction ZOIs and the basis for the ZOIs for each applicable debris constituent.

McGuire Response:
There are three types of insulation debris generated within the ZOIs evaluated for McGuire: Mirror Reflective Metal Insulation (RMI), jacketed/unjacketed Nukon® fiber insulation, and jacketed Thermal-Wrap® fiber insulation. All debris generation estimates within the ZOIs for these types, as reported in the NEI 04-07 guidance, are determined by jet impingement testing.

Table 3B2-1 shows the ZOI radii and destruction pressures for these three McGuire insulation debris types. The ZOIs in this Table reflect the default values given in the NEI 04-07 guidance report. ZOIs for two of the insulation types were refined further as discussed in item 3(b)(3).

Table 3B2-1
ZOI Radii for McGuire Insulation Debris Types

Debris Type	Destruction Pressure (psig)	ZOI Radius/Break Diameter (L/D)
Mirror RMI	2.4	28.6
Nukon® Insulation	6	17
Thermal-Wrap® Insulation	6	17

3(b)(3) Identify if destruction testing was conducted to determine ZOIs. If such testing has not been previously submitted to the NRC for review or information, describe the test procedure and results with reference to the test report(s).

McGuire Response:
Initial ZOIs for insulation debris were determined using the NEI 04-07 guidance report and the companion SER. These ZOIs were based on NRC-evaluated jet impingement testing as described in those documents, and were used in sizing the modified ECCS sump strainers at McGuire. Further refinements to insulation debris ZOIs were incorporated in the Duke IPT for chemical effects as described in the response to RAI #11 of Enclosure 1. These refined ZOIs are also based on specific jet impingement testing on jacketed Nukon® insulation, and are identified in the WCAP-16710-P test report: "Jet Impingement Testing to Determine the Zone of Influence (ZOI) of Min-K and NUKON® Insulation for Wolf Creek and Callaway Nuclear Operating Plants", dated October 2007. The evaluation within WCAP-16710-P demonstrates a refined 7D ZOI for jacketed Nukon® insulation. The design and properties of jacketed Thermal-Wrap® and

jacketed Nukon® insulation are sufficiently similar such that this refined ZOI can be applied to both.

3(b)(4) Provide the quantity of each debris type generated for each break location evaluated. If more than four break locations were evaluated, provide data only for the four most limiting locations.

McGuire Response:
The four most limiting locations for debris generation are those associated with the SG loop LBLOCA breaks (Cases 1 through 4), since these breaks produce the highest Low Density Fiberglass (LDFG) contributions. The estimated generated quantities of insulation debris that follow represent the amounts generated using the initial 17D ZOI described in items (1), (2), and (3) above (i.e., quantities unrefined by WCAP-16710-P).

The quantities of each insulation debris type generated for each of the most limiting break locations are given in Tables 3B4-1 through 3B4-8. Note that the values in parentheses indicate the fraction of the total amount for a specific size distribution.

Table 3B4-1
Non-RMI Debris Quantities - Case 1 (LBLOCA SG Loop A)

Debris Type	Fines	Small Pieces	Unjacketed Large Pieces	Intact Blankets	Total
LDFG Insulation - Crossover	249.0 ft³ (12.4%)	729.5 ft³ (35.5%)	520.3 ft³ (25.3%)	557.6 ft³ (27.1%)	2056.4 ft³
LDFG Insulation - Hot Leg	262.7 ft³ (13.0%)	840.0 ft³ (41.5%)	445.2 ft³ (22.0%)	476.9 ft³ (23.5%)	2024.8 ft³

Table 3B4-2
RMI Debris Quantities - Case 1 (LBLOCA SG Loop A)

Debris Type	Amount Destroyed by Size Distribution					
Total Amount Destroyed	¼"	½"	1"	2"	4"	6"
31,898.2 ft²	1,372 ft² (4.3%)	6,443 ft² (20.2%)	6,667 ft² (20.9%)	8,166 ft² (25.6%)	5,359 ft² (16.8%)	3,892 ft² (12.2%)

Table 3B4-3
Non-RMI Debris Quantities - Case 2 (LBLOCA SG Loop B)

Debris Type	Fines	Small Pieces	Unjacketed Large Pieces	Intact Blankets	Total
LDFG Insulation - Crossover	256.4 ft³ (12.3%)	766.1 ft³ (36.6%)	515.5 ft³ (24.7%)	552.5 ft³ (26.4%)	2090.5 ft³
LDFG Insulation - Hot Leg	272.7 ft³ (13.1%)	891.9 ft³ (42.8%)	444.9 ft³ (21.3%)	476.4 ft³ (22.8%)	2085.9 ft³

Table 3B4-4
RMI Debris Quantities - Case 2 (LBLOCA SG Loop B)

Debris Type	Amount Destroyed by Size Distribution					
Total Amount Destroyed	¼"	½"	1"	2"	4"	6"
31,334 ft²	1,347 ft² (4.3%)	6,329 ft² (20.2%)	6,549 ft² (20.9%)	8,021 ft² (25.6%)	5,264 ft² (16.8%)	3,823 ft² (12.2%)

Table 3B4-5
Non-RMI Debris Quantities - Case 3 (LBLOCA SG Loop C)

Debris Type	Fines	Small Pieces	Unjacketed Large Pieces	Intact Blankets	Total
LDFG Insulation - Crossover	232.0 ft³ (12.5%)	711.6 ft³ (38.4%)	438.2 ft³ (23.7%)	469.5 ft³ (25.4%)	1851.3 ft³
LDFG Insulation - Hot Leg	244.2 ft³ (13.8%)	841.0 ft³ (47.5%)	331.5 ft³ (18.7%)	354.1 ft³ (20.0%)	1770.5 ft³

Table 3B4-6
RMI Debris Quantities - Case 3 (LBLOCA SG Loop C)

Debris Type	Amount Destroyed by Size Distribution					
Total Amount Destroyed	¼"	½"	1"	2"	4"	6"
27,621 ft²	1,188 ft² (4.3%)	5,579 ft² (20.2%)	5,773 ft² (20.9%)	7,071 ft² (25.6%)	4,640 ft² (16.8%)	3,370 ft² (12.2%)

Table 3B4-7
Non-RMI Debris Quantities- Case 4 (LBLOCA SG Loop D)

Debris Type	Fines	Small Pieces	Unjacketed Large Pieces	Intact Blankets	Total
LDFG Insulation - Crossover	226.8 ft³ (12.5%)	691.8 ft³ (38.0%)	435.6 ft³ (23.9%)	466.8 ft³ (25.6%)	1821.0 ft³
LDFG Insulation - Hot Leg	242.3 ft³ (13.5%)	815.8 ft³ (45.5%)	355.3 ft³ (19.8%)	380.4 ft³ (21.2%)	1793.8 ft³

Table 3B4-8
RMI Debris Quantities- Case 4 (LBLOCA SG Loop D)

Debris Type	Amount Destroyed by Size Distribution					
Total Amount Destroyed	¼"	½"	1"	2"	4"	6"
28,802 ft²	1,238 ft² (4.3%)	5,818 ft² (20.2%)	6,020 ft² (20.9%)	7,373 ft² (25.6%)	4,839 ft² (16.8%)	3,514 ft² (12.2%)

3(b)(5) Provide total surface area of all signs, placards, tags, tape, and similar miscellaneous materials in containment.

McGuire Response:
Signs, placards, tags, tape, and similar miscellaneous materials in containment (including dust, dirt, and lint) are defined, for the purposes of the McGuire

modified ECCS sump strainer design and debris generation evaluation, as latent debris and miscellaneous latent debris. The total quantity of latent debris inside containment, and the amount of latent debris estimated to be generated as a result of a LBLOCA, is discussed in detail in Section 3(d) of Enclosure 2.

3(c) Debris Characteristics
The objective of the debris characteristics determination process is to establish a conservative debris characteristics profile for use in determining the transportability of debris and its contribution to head loss.

3(c)(1) Provide the assumed size distribution for each type of debris.

McGuire Response:
Three types of potentially transportable debris are generated at McGuire during a postulated accident: destroyed insulation (fibrous and RMI), failed coatings, and latent debris.

As described in Enclosure 2, Section 3(b), for the initial evaluation of the generation of insulation debris, the ZOIs assumed are consistent with the default values specified in the NEI 04-07 guidance, including the SER.

A refined fiber insulation ZOI and size distribution for jacketed insulation, using the results of specific jet impingement testing reported in WCAP-16710-P, was utilized as an input to the Integrated Prototype Test (IPT) for chemical effects described in detail in the response to RAI #11 of Enclosure 1. This is the only deviation from the SER approved methodology for insulation debris generation. A discussion of the application of this WCAP can be found in Enclosure 2, Section 3(b). The results of the IPT employing these refinements are addressed in the response to RAI #12 of Enclosure 1.

Table 3C1-1 below shows the results of an analysis that supports the use of specific size distributions for the initial fiber insulation debris at McGuire in Computational Fluid Dynamics (CFD) analyses. This analysis utilizes guidance found in the NEI-04-07 SER. For Nukon® and Thermal Wrap® insulation, it was determined that overall fibrous debris size distribution is best defined using three ZOI sub-zones.

Table 3C1-1
McGuire Initial LDFG Debris Distributions

SIZE	18.6 psi ZOI (7.0 L/D)	10.0-18.6 psi ZOI (11.9-7.0 L/D)	6.0-10.0 psi ZOI (17.0-11.9 L/D)
Fines (Individual Fibers)	20%	13%	8%
Small Pieces (<6" on a side)	80%	54%	7%
Large Pieces (>6" on a side)	0%	16%	41%
Intact (covered) Blankets	0%	17%	44%

The size distribution of destroyed RMI, primarily Diamond Power Mirror Insulation at McGuire, is depicted in Figure 3C1-1 below. The destruction pressure for this type of insulation with standard banding is 2.4 psi, which corresponds to a ZOI radius of 28.6 pipe diameters as identified by the NEI-04-07 SER. The size distribution for RMI, as provided in NEI-04-07 guidance and the companion SER, is 75% small pieces and 25% large pieces.

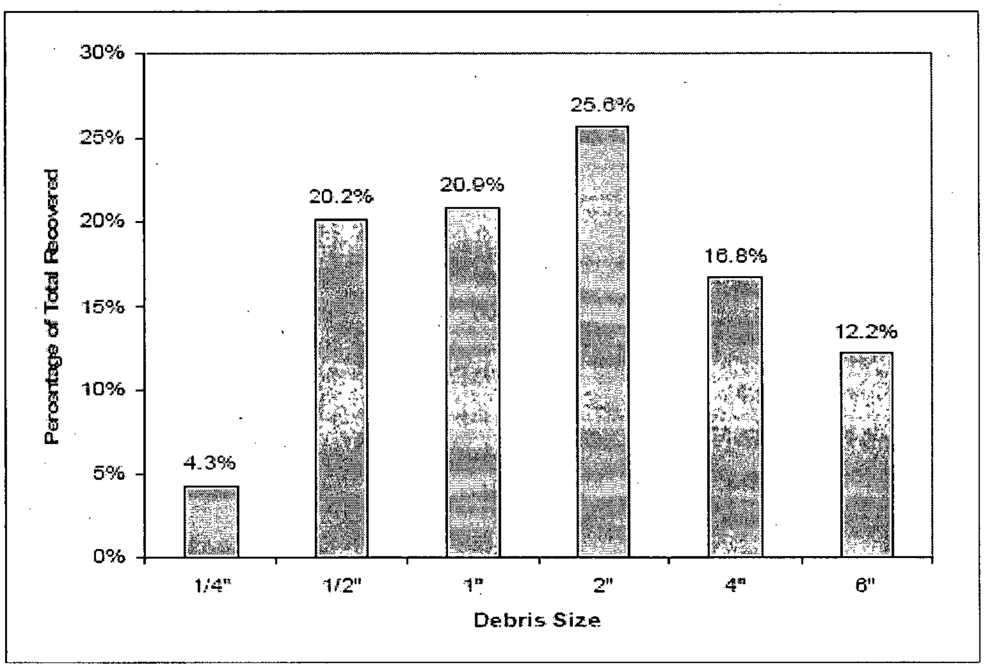


Figure 3C1-1
McGuire RMI Debris Size Distribution

Debris sizes for failed coatings and latent debris (dust, dirt, and lint) can be found in the response to item 2 below. Miscellaneous latent debris (stickers, labels, and tags) is assumed to have various sizes, and is addressed in Section 3(d) of Enclosure 2.

3(c)(2) Provide bulk densities (i.e., including voids between the fibers/particles) and material densities (i.e., the density of the microscopic fibers/particles themselves) for fibrous and particulate debris.

McGuire Response:
NEI 04-07 and the companion SER (Method 2) provide a conservative estimate of the densities of the latent fibers and particulates (94 lb/ft^3 and 169 lb/ft^3, respectively). To be consistent with the head loss analysis, the microscopic density of the latent fiber material is conservatively assumed equivalent to that of Nukon® fiberglass (175 lb/ft^3). The NRC SER also states that the particulate size can be estimated by using the NUREG/CR-6224 head loss data for typical mixtures of latent particulate debris. The latent particulate debris size using this methodology is 17.3 microns. Additionally, the NRC SER (Method 2) states that the latent fiber sizing for head loss purposes is assumed to be the same as reported in NUREG/CR-6224 for commercial fiberglass (approximately 7 microns).

The densities of the different debris types generated at McGuire are summarized in Table 3C2-1 below:

Table 3C2-1
McGuire Generated Debris Characteristics

Debris Material	Macroscopic Density (lb/ft^3)	Microscopic Density (lb/ft^3)	Characteristic Size (μm)	Characteristic Size (ft)
Fiberglass Insulation	2.4	175	7.112*	2.33E-05
Latent Fibers	2.4	175***	7.112*	2.33E-05
Qualified Coatings - Epoxies	N/A	118	10**	3.28E-05
Unqualified Coatings	N/A	94 & 98	10**	3.28E-05
Latent Dirt/Dust	N/A	169	17.3**	5.68E-05

* - fiber diameter
** - spherical particle diameter
*** - latent fiber microscopic density of Nukon® insulation to be consistent with head loss analysis

3(c)(3) Provide assumed specific surface areas for fibrous and particulate debris.

McGuire Response:
The specific debris characteristic sizes used for fibrous and particulate debris in the head loss analysis are provided in Table 3C2-1 in the response to item 2, above.

3(c)(4) Provide the technical basis for any debris characterization assumptions that deviate from NRC-approved guidance.

McGuire Response:
Initial debris characterization assumptions used in the evaluation of estimated generated debris at McGuire are primarily taken from the guidance provided by NEI 04-07 and the associated NRC SER. For the determination of the McGuire fibrous insulation debris size distribution, an extension of the methodology and guidance provided in the NEI 04-07 SER was necessary.

For a baseline analysis, the NEI-04-07 *guidance document recommends* a size distribution with two categories: 60% small fines and 40% large pieces. The SER (Appendix VI, Section 3.2) suggested a more refined approach for determining the debris size distribution based on applicable air jet impact tests. Using Appendices II and VI from the SER, a debris size distribution for Nukon® (and via similarity, Thermal-Wrap®) insulation was developed. It was determined that within the overall break ZOI, the size distribution of fibrous insulation would vary based on the distance of the insulation from the break (i.e., insulation debris generated near the break location would consist of more small pieces than insulation debris generated near the edge of the ZOI). The response to item 3(c)(1) above provides specifics regarding the results of this extended analysis and the resulting assumed size distributions.

Other assumptions regarding debris characteristics are located in the response to RAI #1 of Enclosure 1.

Further refinements (i.e., to jacketed fiber insulation ZOIs and to assumptions related to failed unqualified epoxy coatings) utilizing specific industry testing are incorporated in the Integrated Prototype Test for chemical effects as described by RAI #11 of Enclosure 1, and in Sections 3(b) and 3(h) of Enclosure 2.

3(d) Latent Debris
The objective of the latent debris evaluation process is to provide a reasonable approximation of the amount and types of latent debris existing within the containment and its potential impact on sump screen head loss.

3(d)(1) Provide the methodology used to estimate quantity and composition of latent debris.

McGuire Response:
Latent debris, for the purposes of the modified McGuire ECCS sump strainer design and evaluation, is defined as dirt, dust, paint chips, fibers, paper scraps, plastic tags, tape, adhesive, labels, fines or shards of thermal insulation, fireproof barrier, "owner-installed" material (e.g. signs, stickers, etc.), or other materials that may be present in containment prior to a postulated LOCA.

As discussed in the response to RAI #34 of Enclosure 1, McGuire containment foreign materials walkdowns were conducted using NEI 02-01 guidance for both Units. As a part of these walkdowns, the existence of latent debris was evaluated. The walkdown results were tabulated using walkdown notes and photographs. Only materials that were expected to remain in containment after an outage were included in the inventories.

Subsequent to these walkdowns, a tag and label reduction evaluation was performed to analytically reduce the amount of stickers, labels, and tags that could fail in a postulated LOCA and transport to the ECCS sump pool, using current EQ qualifications and engineering judgment.

An additional 20% was then added to take into account missed materials, areas of low photograph-to-area size ratios, and inaccessible areas due to limited space and high radiation.

The latent debris tabulations were used to develop a reasonable but conservative total square footage of each material by containment area. Generic sampling data (mass densities) from other plants, combined with subjective walkdown observations as to plant cleanliness, were also used to make quantitative estimates of latent debris by containment area.

3(d)(2) Provide the basis for assumptions used in the evaluation.

McGuire Response:
The following discussion provides the assumptions and their bases regarding the treatment of latent debris inside the McGuire containments:

- The amount of dust, dirt, and lint was estimated to be about 90 lb in Unit 2, and 140 lb in Unit 1. A bounding value of 200 lb was used in the debris generation evaluation to provide adequate margin.

- Penetration sealant is assumed to fail only in the break ZOI. Foam sealants are identified only in the upper containment. There are no breaks postulated in upper containment.

- The walkdown report identifies flexible connections in various areas in containment as miscellaneous debris. It is assumed that only the flexible connections within the break ZOI will be destroyed. The only flexible connections identified in the walkdown report are in the Ice Condenser. There are no breaks postulated in the Ice Condenser area. It is reasonable to assume that flexible connections that are outside a break ZOI will not spontaneously fail.

- Per NEI 04-07, the fiber content of the latent dust and dirt debris is assumed to be 15% by mass. With the assumption of 200 lb of latent debris, 30 lb of the debris is considered to be latent fibers. The NRC SER for NEI 04-07 further assumes that the latent fiber bulk density is assumed to be the same as low density fiberglass material (2.4 lb/ft^3). This results in 12.5 ft^3 of latent fibrous debris. NEI 04-07 and the NRC SER Method 2 provide a conservative estimate of the latent fibers and particulate densities (94 lb/ft^3 and 169 lb/ft^3, respectively). To be consistent for the McGuire head loss analysis, the microscopic density of the latent fiber material was assumed to be equivalent to Nukon® fiberglass (175 lb/ft^3). The NRC SER also states that the particulate size can be estimated by using the NUREG/CR-6224 head loss data for typical mixtures of latent particulate debris. The latent particulate debris size using this methodology is 17.3 microns. Additionally, the SER states that the latent fiber sizing for head loss purposes are assumed to be the same as reported in NUREG/CR-6224 for commercial fiberglass (approximately 7 microns).

The following discussion provides the assumptions and their bases for the Tag and Label reduction evaluation in the McGuire containment buildings:

- All assumed percentages are estimated from plant drawings, walkdown experience, and walkdown photos. All percentages were initially estimated and then adjusted to provide conservatism; however, all are based on engineering judgment. The reductions will be applied to the actual tag or label counts and then rounded up to the nearest whole number (i.e. there are no partial tags or labels).

- All tags and labels that detach from their affixed positions are assumed to fall straight down when in the presence of containment spray only (i.e. no submergence and no jet impingement). The same assumption applies when containment spray is not present, such as in the accumulator and fan rooms above the maximum flood level.
- A large portion of the tags and labels inside the crane wall in lower containment will be in the break's zone of influence (ZOI) and will fail. It is not possible to conservatively estimate the percentage of tag and label surface area that is in the ZOI; therefore, all tags and labels inside the crane wall in lower containment will be assumed to fail.
- Plastic tags outside the ZOI are assumed to stay intact. While there may be some deformation due to the LOCA environment, they are assumed to not become overly pliable (i.e. they will not deform to pass through an obstruction that has a smaller dimension than the tag).

3(d)(3) Provide results of the latent debris evaluation, including amount of latent debris types and physical data for latent debris as requested for other debris under c. above.

McGuire Response:
Latent debris quantities are summarized in Tables 3D3-1 and 3D3-2 below.

Table 3D3-2 represents the McGuire Unit 2 latent debris quantities which were assumed bounding for Unit 1; this assumption was subsequently verified. The quantities tabulated include a tag and label refinement evaluation performed utilizing current EQ qualifications and engineering judgment, as identified in the response to item 3(d)(1) above.

Table 3D3-1
McGuire Latent Debris Quantity (Dust, Dirt, and Lint)

Latent Debris Type	Weight	Volume
Dirt and Dust	170 lb	N/A
Latent Fibers (lint)	30 lb	12.5 ft^3 *

* Based on a bulk density of 2.4 lb/ft^3, similar to LDFG (see assumptions in response to item 2)

Physical data for dust, dirt, and lint debris types can be found in the response to item 3(d)(2) above.

Table 3D3-2
McGuire Refined Miscellaneous Latent Debris Quantities

Type of Debris	Lower Containment (Inside Crane Wall)	Lower Containment (Outside Crane Wall)	Upper Containment	Ice Condenser	Total
Stickers & Labels (ft^2)	64.96	30.34	14.43	8.92	118.65
Plastic Tags w/ Adhesive (ft^2)	33.32	8.79	11.23	8.02	61.36
Plastic Hanging Tags (ft^2)	11.70	4.33	N/A	0.17	16.20
RMI ID Stickers (ft^2)	103.14	32.81	N/A	N/A	135.95
Ice Condenser Debris (ft^2)	N/A	N/A	N/A	15.30	15.30
Total (ft^2)	N/A	N/A	N/A	N/A	347.5

3(d)(4) Provide amount of sacrificial strainer surface area allotted to miscellaneous latent debris.

McGuire Response:
The miscellaneous latent debris total area contribution to sump strainer blockage at McGuire is 347.5 square feet, as shown in Table 3D3-2 in the response to item 3(d)(3) above.

NEI 04-07 guidance recommends that 75% of the total miscellaneous latent debris transporting to the ECCS sump pool be allotted to sump strainer blockage.

3(e) Debris Transport
The objective of the debris transport evaluation process is to estimate the fraction of debris that would be transported from debris sources within containment to the sump suction strainers.

3(e)(1) Describe the methodology used to analyze debris transport during the blowdown, washdown, pool fill-up, and recirculation phases of an accident.

McGuire Response:
The methodology used to analyze debris transport during the blowdown, washdown, pool fill-up, and recirculation phases of an accident is as follows:

1. Based on containment building drawings, a three-dimensional model was built using computer aided drafting (CAD) software.
2. A review was made of the drawings and CAD model to determine transport flow paths. Potential upstream blockage points including screens, grating, drains, etc. that could lead to water holdup were addressed.
3. Debris types and size distributions were gathered from the debris generation calculation for each postulated break location.
4. The fraction of debris blown to various areas of containment was determined based on the flow of steam during the blowdown.
5. The quantity of debris washed down by ice melt and spray flow was conservatively determined.
6. The quantity of debris transported to inactive areas or directly to the sump screen during pool fill-up was determined to be negligible.
7. Using conservative assumptions, the locations of each type/size of debris at the beginning of recirculation was determined.
8. A Computational Fluid Dynamics (CFD) model was developed to simulate the flow patterns that would occur during recirculation. Further details regarding the CFD model are located in the response to item 3 below.
9. A graphical determination of the transport fraction of each type of debris was made using the velocity and Turbulent Kinetic Energy (TKE) profiles from the CFD model output, along with the determined initial distribution of debris.
10. The recirculation transport fractions from the CFD analysis were gathered to input into the logic trees.
11. The quantity of debris that could experience erosion due to the break flow, spray flow, or ice melt drainage was determined.

The overall transport fraction for each type of debris was determined by combining each of the previous steps in the logic tree.

3(e)(2) Provide the technical basis for assumptions and methods used in the analysis that deviate from the approved guidance.

McGuire Response:
The methodology used in the McGuire debris transport analysis is based on the NEI 04-07 guidance report for refined analyses, as modified by the NRC SER, as well as the refined methodologies suggested by the SER in Appendices III, IV, and VI. The specific effect of each mode of transport was analyzed for each type of debris generated, and a logic tree was developed to determine the total transport to the ECCS sump strainer. Assumptions used in the McGuire debris transport analysis are listed in the response to RAI #1 of Enclosure 1.

The following methodology used in the evaluation deviates from the NEI 04-07 guidance and the companion NRC SER:

- The logic tree approach was different than the baseline logic tree provided in the NEI 04-07 guidance report. The change was made to account for non-conservative assumptions identified by the NEI 04-07 SER, including the transport of large pieces, erosion of small and large pieces, the potential for washdown debris to enter the pool after inactive areas have been filled, and the direct transport of debris to the sump strainer during pool fill-up.

- NEI 04-07 Section 3.4.3 recommends using a two-category size distribution for insulation debris including: (1) small pieces (assumed to be the basic constituent of the material), and (2) large pieces (pieces greater than 4 inches). Although adequate, this size distribution allows for only limited benefit when CFD analyses are used to refine the recirculation pool debris transport fractions. The NRC recognized this limitation in their NEI 04-07 SER. SER Section 4.2.4 recommends a four-category size distribution:

  - Fines that remain suspended
  - Small piece debris that is transported along the pool floor
  - Large piece debris with the insulation exposed to potential erosion
  - Large debris with the insulation still protected by a covering, thereby preventing erosion

  The methodology that can be used to determine the fraction of debris falling within each of the four categories was explained in Appendices II and VI of the SER, but was not fully carried out.

For McGuire debris transport analysis, a complete methodology necessary for assigning a four-category size distribution for low density fiberglass (LDFG) was utilized for initial debris generation calculations. Analysis of LDFG insulating materials demonstrates that the fraction of fines and small pieces decreases with increasing distance from the break jet, and the fraction of large pieces and intact blankets increases with increasing distance for LDFG.

Additionally, a refined ZOI and size distribution for jacketed fiber insulation, using the results of specific jet impingement testing reported in WCAP-16710-P, was utilized as an input to the Integrated Prototype Test (IPT) for chemical effects described in detail in the response to RAI #11 of Enclosure 1. A discussion of the application of this WCAP can be found in Enclosure 2, Section 3(b). The results of the IPT employing these and other refinements are addressed in the response to RAI #12 of Enclosure 1.

3(e)(3) Identify any computational fluid dynamics codes used to compute debris transport fractions during recirculation and summarize the methodology, modeling assumptions, and results.

McGuire Response:
The CFD calculation for recirculation flow in the McGuire containment sump pool was performed using Flow-3D® Version 9.0.

The CFD model was generated based on the following characteristics:

1. The mesh in the CFD model was nodalized to sufficiently resolve the features of the CAD model, but still keep the cell count low enough for the simulation to run in a reasonable amount of time.
2. The boundary conditions for the CFD model were set based on the configuration of McGuire during the recirculation phase.
3. The ice melt and containment spray flows were included in the CFD calculation, with the appropriate flowrate and kinetic energy to accurately model the effects on the containment sump pool.
4. At the postulated break location, a mass source was added to the model to introduce the appropriate flowrate and kinetic energies associated with the break flow.
5. A negative mass source was added at the sump pool location with a total flowrate equal to the sum of the spray flow and break flow.
6. An appropriate turbulence model was selected for the CFD calculations.

7. After running the CFD calculations, the mean kinetic energy was checked to verify that the model had been run long enough to reach steady-state conditions.
8. Transport metrics were determined based on relevant tests and calculations for each significant debris type present in the McGuire containment break ZOIs.

Assumptions used in the CFD model are as follows:

1. It was assumed the recirculation transport fractions determined for the McGuire Loop B break can be applied to the other breaks inside the crane wall. This is a conservative assumption since the Loop B break location is closest to the ECCS sump strainer.
2. The water falling from the reactor coolant system break was assumed to do so without encountering any structures before reaching the containment sump pool. This is a conservative assumption since any impact with structures would dissipate the momentum of the water and decrease the turbulent energy in the pool.
3. It was assumed that potential upstream blockage points (e.g., drains, fences, grating, etc.) would not inhibit the flow of water.

Logic trees were used to determine the fractions of the various types of debris that would reach the containment sump pool. Since the recirculation transport fractions are assumed to be the same for each of the breaks inside the crane wall, the overall transport fraction would also be the same. Logic trees were constructed for small RMI debris, large RMI debris, small low density fiberglass debris, and large low density fiberglass debris. For all RMI debris, it was determined that no debris would transport to the active pool. In addition, since the latent fiber, dirt/dust, and paint particulate were all assumed to reach the recirculation pool and the recirculation transport fraction is 100%, the overall transport fraction is also 100%.

Logic trees are shown in Figures 3E3-1 and 3E3-2 below for small piece fiberglass debris and large piece fiberglass debris, respectively:

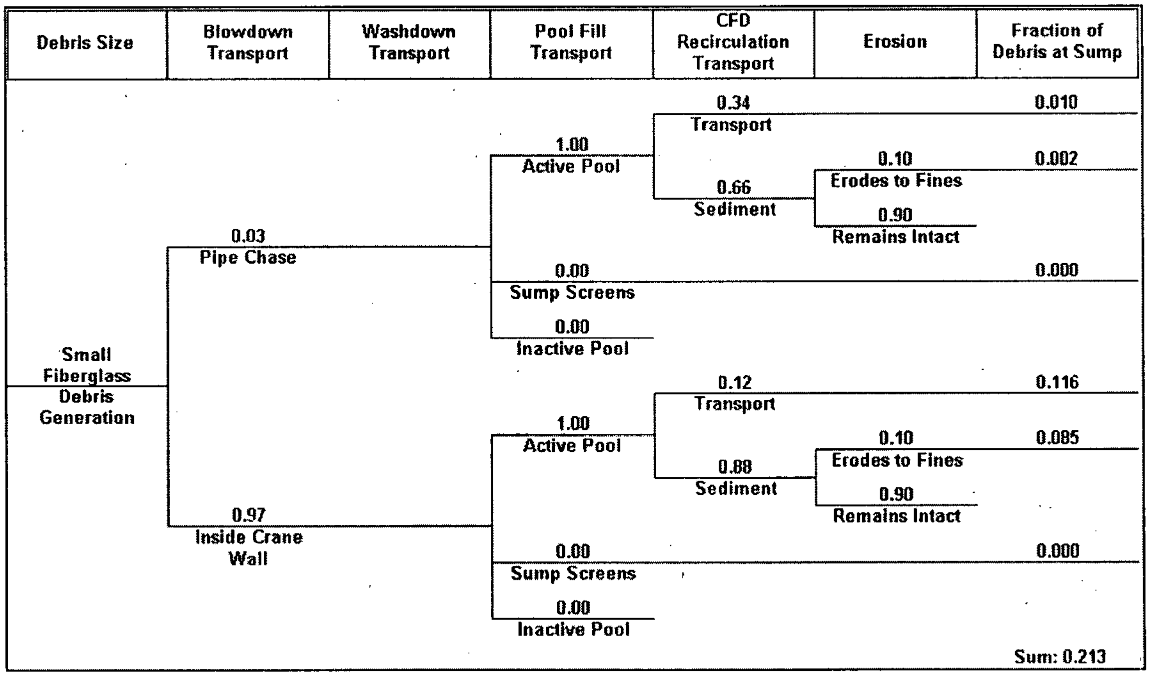


Figure 3E3-1

McGuire Small Piece Fiberglass Debris Transport Logic Tree

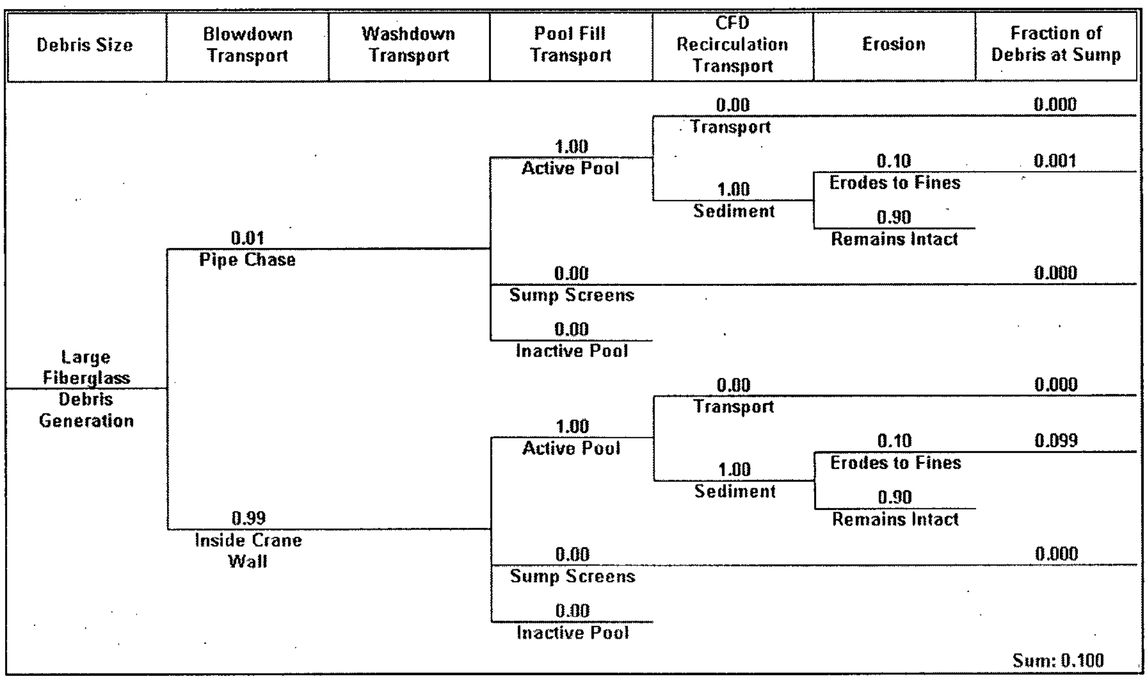


Figure 3E3-2

McGuire Large Piece Fiberglass Debris Transport Logic Tree

3(e)(4) Provide a summary of, and supporting basis for, any credit taken for debris interceptors.

McGuire Response:
The design and placement of the McGuire modified ECCS sump strainer provides for the filtration of large debris entrained in the sump pool prior to reaching the strainer via passage of water through openings in the crane wall (credited) for those portions of the strainer located outside the crane wall, or through 3/32 inch openings in the strainer enclosure (not credited) for that portion of the strainer located inside the crane wall.

For the credited flowpath, water reaches the sump strainer after first passing through the crane wall penetrations. Thus, entrained debris is allowed to settle and be filtered by passage through crane wall penetrations prior to reaching the strainer. For the uncredited flowpath, water reaches the strainer by passing through the ECCS strainer enclosure. The enclosure surrounding the strainer portion located inside the crane wall has perforated sides with 3/32 inch diameter holes. This path is not credited due to the potential for blockage by the projected fiber debris load. Either flowpath will effectively prevent large debris from reaching the strainer assemblies.

3(e)(5) State whether fine debris was assumed to settle and provide basis for any settling credited.

McGuire Response:
As discussed in the response to RAI #37 of Enclosure 1, for each postulated break, fine debris (i.e., dust, dirt, lint, and failed coatings particulates) was assumed to transport 100% to the McGuire containment sump pool. Upstream fine debris settling is not credited in the head loss testing nor in the analytical design basis of the McGuire modified ECCS sump strainers.

3(e)(6) Provide the calculated debris transport fractions and the total quantities of each type of debris transported to the strainers.

McGuire Response:
Of the five McGuire postulated breaks, the most limiting break is the Reactor Coolant System Hot Leg break in Steam Generator Loop B. The initial calculated debris transport fractions and the total quantities of each type of debris transported to the strainers for the Case 2 Hot Leg break are given in Table 3E6-1 below. As discussed in item 3(e)(2) above, refinements to the ZOI and size

distribution for jacketed fibrous insulation are being incorporated into the final ECCS sump strainer performance evaluation.

Table 3E6-1

Initial Debris Transport to McGuire ECCS Sump Strainers Case 2 (LBLOCA SG Loop B Hot Leg)

Debris Type	Debris Size	Debris Quantity Generated	Debris Transport Fraction	Debris Quantity at Sump
Stainless Steel RMI	Small Pieces (<4")	22,246 ft^2	0%	0 ft^2
	Large Pieces (>4")	9,087 ft^2	0%	0 ft^2
	Total	**31,333 ft^2**	**0%**	**0 ft^2**
Nukon® and Thermal-Wrap® LDFG (Hot Leg Break)	Fines	272.7 ft^3	100%	272.7 ft^3
	Small Pieces (<6")	891.9 ft^3	21%	187.3 ft^3
	Large Pieces (>6")	444.9 ft^3	10%	44.5 ft^3
	Intact Pieces (>6")	476.4 ft^3	0%	0 ft^3
	Total	**2,085.9 ft^3**	**24%**	**504.5 ft^3**
Qualified Epoxy (5D ZOI)	Total (fines)	167.6 lb	100%	167.6 lb
Unqualified Epoxy	Total (fines)	654.2 lb	100%	654.2 lb
Unqualified Alkyd	Total (fines)	15.7 lb	100%	15.7 lb
Dirt/Dust	Total (fines)	170 lb	100%	170 lb
Latent Fiber	Total (fines)	12.5 ft^3	100%	12.5 ft^3
Other Latent Debris	Total	347.5 ft^2	100%	347.5 ft^2

3(f) Head Loss and Vortexing

The objectives of the head loss and vortexing evaluations are to calculate head loss across the sump strainer and to evaluate the susceptibility of the strainer to vortex formation.

General McGuire Response Note
The head loss testing and analysis described in this Section reflect the McGuire ECCS sump strainer in a clean and debris loaded condition (i.e., fiber, particulate, and latent debris). Chemical effects on the debris loaded condition of the strainer are addressed in Section 3(o) of Enclosure 2.

3(f)(1) Provide a schematic diagram of the emergency core cooling system (ECCS) and containment spray systems (CSS).

McGuire Response:
The ECCS schematic for McGuire is shown in Figure 3F1-1 following. The CSS schematic for McGuire is shown in Figure 3F1-2 following.

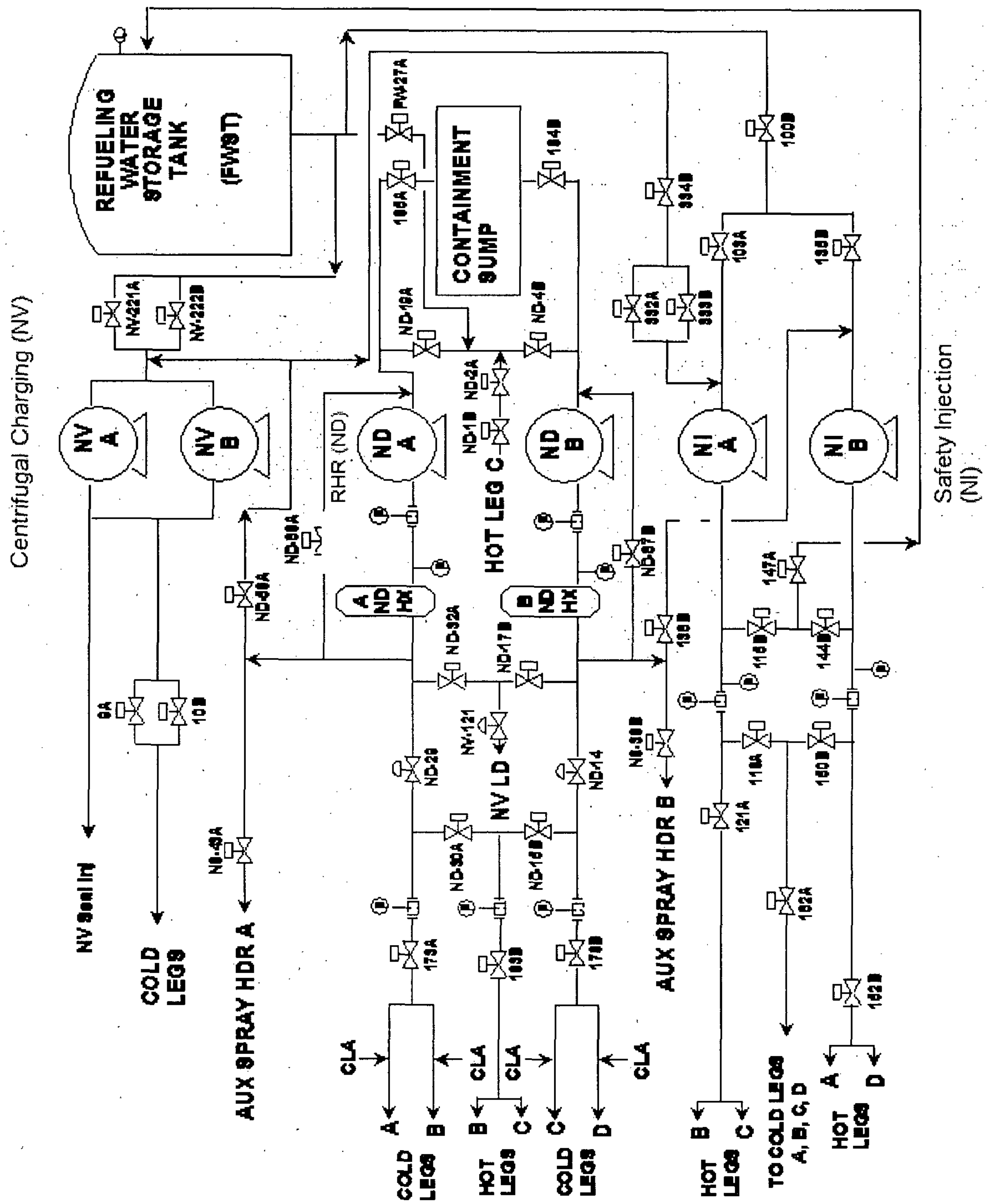


Figure 3F1-1

McGuire Emergency Core Cooling System

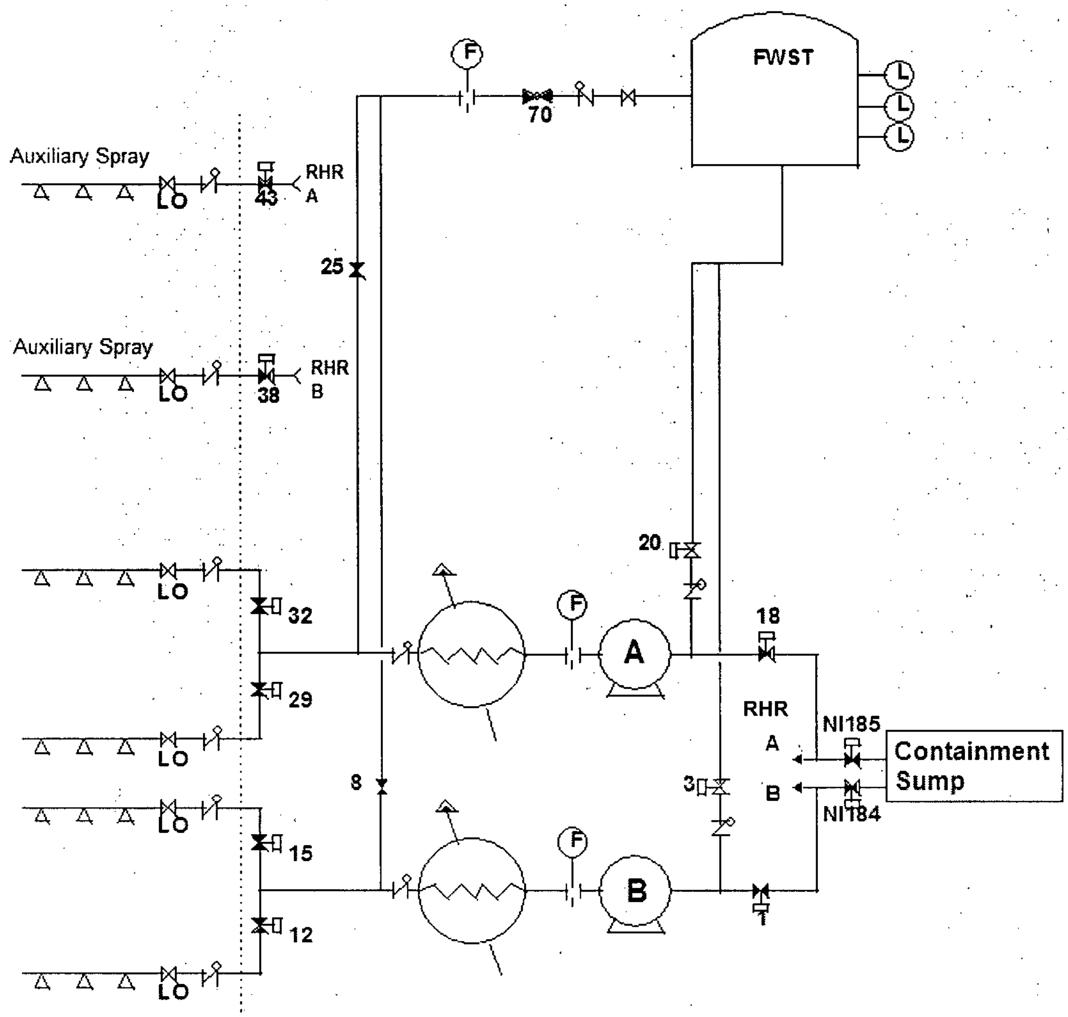


Figure 3F1-2

McGuire Containment Spray System

3(f)(2) Provide the minimum submergence of the strainer under small-break loss-of-coolant accident (SBLOCA) and large-break loss-of-coolant accident (LBLOCA) conditions.

McGuire Response:
As discussed in the response to RAI #41 of Enclosure 1, the limiting analytical case for minimum ECCS sump level at McGuire is characterized as a small break LOCA (SBLOCA) during which Containment Spray does not actuate and there is no water source contribution from ice melt. The minimum submergence

of the McGuire ECCS sump strainer under postulated SBLOCA conditions is at least 2 inches.

The various large break LOCA (LBLOCA) cases generate more water and more submergence than the limiting SBLOCA case outlined above. The LBLOCA cases will have an Ice Condenser contribution to ECCS sump inventory due to ice melt, and at larger postulated break sizes, additional containment sump pool contributions from the RCS and the Cold Leg Accumulator Tanks.

3(f)(3) Provide a summary of the methodology, assumptions and results of the vortexing evaluation. Provide bases for key assumptions.

McGuire Response:
NUREG-0897 summarizes the results of testing performed at Alden Research Laboratory that determined the susceptibility of forming a vortex in typical PWR sumps. The results of this testing are also contained within Regulatory Guide 1.82. This testing was based on sump layouts that included an open pit with single or dual horizontal and vertical intakes and a screen outside and above the pit. For McGuire, the entire 725'+0" elevation is considered the "sump" and there is no actual pit. The new strainer (including top-hats, flow plenums, and waterboxes) is located on the floor in the sump with multiple suction points into the strainer, and a much greater strainer surface area from which to draw flow. Therefore, the vortex formation parameters presented in Regulatory Guide 1.82 are considered to be overly conservative.

The top-hat strainer modules are completely covered by horizontal standard floor grating for the purpose of vortex suppression. The top of the grating inside the crane wall is also covered by 14 gauge solid plate. The minimum containment water level is at least 3 feet above the sump floor; at this water level, both vortex suppression gratings are fully submerged (by at least 2 inches as noted previously) and provide assurance that the suction lines will not be susceptible to air ingestion caused by air core vortex formation from the post-LOCA containment building water surface.

Top-hat strainer module testing demonstrates that standard floor grating eliminates air core vortices for top-hat approach velocities ranging from 0.01 ft/sec to 0.09 ft/sec. This testing was performed with a few inches of water coverage above the top hat modules similar to the top hat modules at McGuire. The maximum approach velocity for the top hat modules is approximately 0.052 ft/sec. Since the maximum approach velocity for the top-hat modules at McGuire is within the tested flow condition, and since the submergence is consistent with the tested condition, the McGuire top-hat strainer modules are not susceptible to air ingestion from an air core vortex.

The vortexing evaluation is described further and summarized in the response to RAI #39 of Enclosure 1.

3(f)(4) Provide a summary of the methodology, assumptions, and results of prototypical head loss testing for the strainer, including chemical effects. Provide bases for key assumptions.

McGuire Response:
A detailed discussion of the methodology, design inputs, and assumptions regarding Duke's prototypical head loss testing for the McGuire ECCS sump strainer top-hat modules (i.e., the Integrated Prototype Test (IPT) including chemical effects) is located in the response to RAI #11 of Enclosure 1.

Initial prototypical head loss testing for the McGuire top-hat strainer modules was performed during an array test, during which various quantities of debris (i.e., fiber and particulate) were allowed to collect on the modules while head loss measurements were made. The data collected from this testing was used to generate a head loss correlation which is used in determining the total head loss across the ECCS sump strainer. Chemical effects on the strainer debris bed are demonstrated via a different prototype test as identified below.

The total calculated head loss of the strainer consists of four parts:

- Head loss across the debris bed (based on top-hat module array test data)
- Head loss across the clean perforated plate mesh surfaces in the top-hats (based on hydraulic analysis)
- Head loss through the waterbox/plenum arrangement connecting the array of top-hats to the ECCS suction piping (based on hydraulic analysis)
- Head loss due to cumulative chemical effects across debris-loaded top-hats (based on the IPT chemical effects data)

The response to RAI #12 of Enclosure 1 indicates that the final head loss calculation will be performed and documented upon the finalization of the IPT. Upon completion of the IPT documentation, a refined debris load head loss calculation will be generated that incorporates any added consequence of tested chemical effects. This is a commitment identified in Duke letter dated November 6, 2007, "Request for Extension of Completion Dates for McGuire Units 1 and 2 Corrective Actions Required by NRC Generic Letter (GL) 2004-02". Duke expects to have this documentation, and to supplement the response to RAI #12, by April 30, 2008.

3(f)(5) Address the ability of the design to accommodate the maximum volume of debris that is predicted to arrive at the screen.

McGuire Response:
As discussed in the response to RAI #40 of Enclosure 1, the predicted head loss for the McGuire modified ECCS sump strainer utilizes test data obtained from a prototypical top-hat module array (2 high × 3 wide). The top-hats used in this array testing were 36 inches long, as this length is representative of the population of top-hat modules on the McGuire strainers. The array test used debris loads (i.e., particulates and fiber) in various quantities postulated to transport to the containment sump after a large-break LOCA. Section 3(e) of Enclosure 2 discusses the debris quantities expected to transport to the McGuire ECCS sump strainer.

Expected Design Behavior
The debris bed initially accumulates non-uniformly on the top-hat. The approach velocity will vary across the individual top-hats and across the array based on the location of the top-hats relative to the suction source. As the debris bed builds up to the maximum load, the debris bed starts to fill the interstitial volume and begins to transition to the circumscribed area of the strainer. Transitioning to the circumscribed area changes the strainer from a complex shape (multiple cylinders with flow passages outside and inside the cylinder) to a simple cylindrical shape with a single outer flow passage. This transition results in a decreased surface area and increased head loss. The debris bed at this point is also more uniform than the thinner beds and results in increased head loss. As the debris bed is more uniform for the maximum load, flow through the debris bed is more uniform and head loss is governed by the bed thickness and approach velocity.

3(f)(6) Address the ability of the screen to resist the formation of a "thin bed" or to accommodate partial thin bed formation.

McGuire Response:
The thin-bed effect is defined as the relatively high head losses that occur across a uniform thin bed of fibrous debris that can sufficiently filter particulate debris to form a dense particulate debris bed. The thin-bed effect is typically seen in testing of a strainer with a simple geometry such as a flat plate. Strainer designs with a more complex geometry are more likely to load non-uniformly, precluding the formation of a thin bed.

The top-hat modules used on the modified McGuire ECCS sump strainers consist of hollow concentric cylinders mounted on a square base. The cylinders are comprised of stainless steel perforated plate.

A series of tests were performed on this top-hat module design for the purpose of determining the head loss at high particulate/fiber ratios. The measured head loss conservatively bounded any head loss that could be achieved with varying fiber quantities. No indication of a thin-bed effect was observed.

Based on results of this testing, it can be concluded that the modified McGuire ECCS sump strainer utilizing an array of strainer modules (top-hats) that do not exhibit thin-bed formation.

The Integrated Prototype Test (IPT) was designed to replicate this feature of the top-hat modules also. The results of this testing, to be reported in spring 2008 as noted in item 3(f)(4) above, are expected to further confirm this conclusion.

3(f)(7) Provide the basis for the strainer design maximum head loss.

<u>McGuire Response:</u>
The predicted maximum head loss across the strainer is associated with the maximum debris generation case, the maximum debris transport to the ECCS sump pool, the maximum flowrates in the ECCS sump pool, and the lowest sump pool temperature.

3(f)(8) Describe significant margins and conservatisms used in the head loss and vortexing calculations.

<u>McGuire Response:</u>
The assumptions and conservatisms included in the McGuire debris generation evaluation, the debris transport evaluation, and the vortex suppression evaluation are listed and discussed in the response to RAIs #1 and #39 of Enclosure 1. In addition, Sections 3(b), 3(c), 3(d), and 3(h) of Enclosure 2 detail many conservatisms incorporated into the postulated debris challenge at the strainer. This information ultimately applies to both the head loss and vortex calculations, as the ECCS sump strainer and its predicted performance are analytically downstream of the debris quantifications. Significant conservatisms incorporated in the design of the strainer are listed below.

McGuire ECCS Sump Strainer Head Loss Conservatisms

- For the Inside the Crane Wall Enclosure structure, substantial perforated plate area is not credited for large debris capture.
- The quantities of debris that transport to the McGuire modified ECCS sump strainer are conservative due to maximum transport assumptions.

- The curbs around the refueling canal and Containment Air Return Fan pits existing in Upper Containment will act as large debris interceptors, but are not credited in the transport evaluation.
- No credit is taken for debris remaining on structures and equipment above the pool water level.
- No credit is taken for the shielding of insulation and coatings by major equipment in the break ZOI.
- The initial fibrous debris volume from destroyed insulation used for sizing the modified McGuire ECCS sump strainer is based on a 17D break zone-of-influence (ZOI). As discussed in Section 3(b) of Enclosure 2, WCAP-16710-P recommends a 7D ZOI for jacketed fiber insulation based on specific testing.
- The failed coatings debris volume used for sizing the McGuire modified ECCS sump strainer is conservatively high.
- The assumed flowrate in the McGuire ECCS sump strainer head loss calculations is conservatively high.
- The assumed temperature in the McGuire ECCS sump strainer head loss calculations is conservatively low.

McGuire ECCS Sump Strainer Vortex Evaluation Conservatisms

- As discussed in item 3(f)(3) above, a range of approach velocities were tested in the vortex suppression evaluation; the highest strainer approach velocities tested were higher than the nominal velocities predicted to occur in the McGuire ECCS sump by a factor of three or more. The vortex suppressor successfully eliminated the vortices at all tested approach velocities.
- The water level during the vortex suppression evaluation was maintained only 3 inches above the top surface of the top-hat perforated plate (the expected minimum water level above the top-hat perforated plate at McGuire is about 4 inches).

3(f)(9) Provide a summary of the methodology, assumptions, bases for the assumptions, and results for the clean strainer head loss calculation.

McGuire Response:

Methodology
The following methodology is used to calculate the Clean Strainer Head Loss (CSHL):

1. The strainer net surface area was determined. The net area is defined as the top-hat perforated plate surface area less the area which is unable to take flow due to blockage by stiffener rings, solid margins, or other structural steel.
2. The head loss through a single top-hat is calculated, using data from the Top-hat Array testing.
3. The head loss due to the flow traveling through the plenum was calculated.
4. In order to estimate head loss through the plenum, a hydraulic diameter was calculated for each section with a unique cross sectional area.
5. The largest head loss experienced by a top-hat for its respective flow condition and the plenum head loss was summed to produce the most conservative clean strainer head loss.
6. The Clean Strainer Head Loss is calculated for both Train A and Train B suction lines of the Emergency Core Cooling System, which are supplied recirculation water through redundant headers. The McGuire ECCS sump strainer consists of five major sections per train: the Extension header, the Inside the Crane Wall Section (wing plenums), the 18-inch pipe header, the Outside the Crane Wall (OCW, or Pipechase) Section, and the OCW middle header. Significant cases considered when calculating the Clean Strainer Head Loss are:
    - Two-train RCS Cold Leg recirculation with Safety Injection to RCS Hot Leg (Higher flows with Safety Injection aligned to Hot Leg as opposed to Cold Leg)
    - ECCS Recirculation with Safety Injection to RCS Hot Leg; RHR to Charging/SI isolation valve (ND-58A) closed; "A" train RHR not operating

Assumptions/Bases
The following assumptions are made for the Clean Strainer Head Loss calculation:

1. Steady, incompressible flow is assumed. By definition, the system is water-solid and single-phase.

2. The lowest sump water temperature is assumed to be constant at 60°F. For dynamic head losses, this is conservative.
3. The containment pressure is assumed to be 14.7 psia. This assumption is reasonable because the water properties associated with pressure are not significantly affected by the pressure term.
4. The head loss across the strainer top-hat modules (including the knitted wire mesh bypass eliminator feature) as a function of the approach velocity is determined by prototype array testing.
5. Head losses associated with minor obstructions in the flow path are assumed to be negligible.
6. The effective roughness for commercial steel pipe is used for the stainless steel plenum.
7. The modeling of the enclosure is done using a flow path with conservative losses. Relative to the overall head loss of the strainer, the numbers utilized are small. Thus, using an approximate flow path is reasonable.

McGuire Clean Strainer Head Loss
The McGuire clean strainer head loss, based on the installed Unit 1 strainer area, is calculated as 5.3 feet of water for the maximum recirculation flow condition, and 3.54 feet of water for single train RHR/two-train CS operation.

The McGuire Unit 2 ECCS sump strainer has not yet been completed; it will be fully installed in spring 2008. The Unit 2 strainer, when completed, will be approximately the same size as the installed McGuire Unit 1 strainer.

3(f)(10) Provide a summary of the methodology, assumptions, bases for the assumptions, and results for the debris head loss analysis.

McGuire Response:
The responses provided in items 3(f)(4), 3(f)(5), 3(f)(7), 3(f)(8) and 3(f)(9) of this section address the methodology, assumptions, bases for assumptions, and results for the McGuire ECCS sump strainer debris bed head loss analysis.

3(f)(11) State whether the sump is partially submerged or vented (i.e. lacks a complete water seal over its entire surface) for any accident scenarios and describe what failure criteria in addition to loss of net positive suction heard (NPSH) margin were applied to address potential inability to pass the required flow through the strainer.

McGuire Response:
As discussed in the response to RAI #38 of Enclosure 1, there are no vents or other penetrations through the modified McGuire ECCS strainer connecting the interior of the strainer to the containment atmosphere above the containment minimum water level. The McGuire strainer is designed to be fully submerged, and as discussed in the response to RAI #41 of Enclosure 1, is fully submerged even in the bounding SBLOCA scenario.

3(f)(12) State whether near-field settling was credited for the head-loss testing and, if so, provide a description of the scaling analysis used to justify near-field credit.

McGuire Response:
Upstream debris settling due to the "near-field effect" is not credited in the head loss testing or in the analytical design basis of McGuire's modified ECCS sump strainers.

3(f)(13) State whether temperature/viscosity was used to scale the results of the head loss tests to actual plant conditions. If scaling was used, provide the basis for concluding that boreholes or other differential-pressure induced effects did not affect the morphology of the test debris bed.

McGuire Response:

The top-hat array testing that generated the head loss correlations for the McGuire ECCS sump strainer top-hats was performed at room temperature, which required that a temperature coefficient be used to scale the head loss results to plant conditions.

As discussed in item 3(f)(8) above, the debris generation and debris transport calculations used to size the McGuire modified ECCS sump strainer produced conservative debris loads. These debris loads were incorporated into the prototype top-hat array test, which was performed to evaluate the top-hat performance under various debris loading conditions.

The prototype array thick bed testing demonstrated the bridging of fibrous debris between the top-hat strainer modules arranged in a 2 × 3 array (i.e., filling in the interstitial volume). The intent of the testing was to show that this bridging, and the subsequent uniform debris loading of the modules, resulted in higher head loss than the thin bed test scenarios. Under these conditions, the interstitial volume of the top-hats is completely filled with fibrous debris, and no evidence of anomalous debris bed formation, including boreholes or other differential-pressure induced effects, was observed that was attributed to the test temperature.

The Duke Integrated Prototype Test (IPT) for chemical effects, described in the response to RAI #11 of Enclosure 1, used the predicted McGuire post-DBA containment sump pool temperature cool-down profile, so no temperature coefficient is necessary.

3(f)(14) State whether containment accident pressure was credited in evaluating whether flashing would occur across the strainer surface, and if so, summarize the methodology used to determine the available containment pressure.

McGuire Response:
Containment DBA pressure is not credited in the modified McGuire ECCS sump strainer design.

3(g) Net Positive Suction Head (NPSH)

The objective of the NPSH section is to calculate the NPSH margin for the ECCS and CSS pumps that would exist during a loss-of-coolant accident (LOCA) considering a spectrum of break sizes.

3(g)(1) Provide applicable pump flow rates, the total recirculation sump flow rate, sump temperature(s), and minimum containment water level.

<u>McGuire Response:</u>
The McGuire ECCS/CS pump alignment in the containment sump pool recirculation mode requires that the Residual Heat Removal System pumps, taking suction from the sump pool, supply both the Safety Injection and Charging System pump inlets to ensure adequate NPSH is available. The Containment Spray System pumps take flow from the containment sump pool in recirculation mode as well.

Table 3G1-1 below lists the applicable flowrates for the McGuire RHR/CS pumps. The flowrates given in this table are representative flowrates for both Unit 1 and Unit 2.

Table 3G1-1
McGuire RHR / CS Pump Flow Rates

	Flow at Available NPSH	Flow at Required NPSH
Residual Heat Removal Pump Flow	4819 gpm	5000 gpm
Containment Spray Pump Flow	3670 gpm	4000 gpm

Other information requested follows.

- Total ECCS Sump Pool Recirculation Flow Rate: The limiting NPSH margin for the CS pumps and RHR pumps is two-train RHR/CS recirculation operation with SI to the RCS Hot Leg and the RHR to Charging/SI isolation valve closed, which results in a total analyzed recirculation flow of 15,700 gpm. Additionally, the single train RHR/two-train CS operation results in the limiting NPSH for the CS pumps which results in a recirculation flow of 12,100 gpm.
- ECCS Sump Pool Temperatures: 190°F, decreasing to 90°F. As discussed in the response to RAI #11 of Enclosure 1, 190°F is the peak temperature at

the beginning of ECCS sump pool recirculation; the pool temperature declines rapidly after initiation of recirculation, ultimately reaching 90°F at the end of the ECCS mission time.

- ECCS Sump Pool Minimum Water Level: As discussed in the response to RAI #41 of Enclosure 1, the limiting analytical case for minimum ECCS sump level at McGuire is characterized as a SBLOCA during which Containment Spray does not actuate and there is no water source contribution from ice melt. For this SBLOCA scenario, a sump pool level of 36 inches above the sump floor is calculated, which represents a submergence level of at least 2 inches above the top of the vortex suppressors.

3(g)(2) Describe the assumptions used in the calculations for the above parameters and the sources/bases of the assumptions.

McGuire Response:

General Assumptions

- No credit is taken for increased containment pressure during an accident.
- Containment ECCS sump pool temperature is 190°F.
- ECCS sump minimum level (floor) elevation of 725'+0" is used to determine the available NPSH.
- The SI/Charging pump required NPSH is based on single pump run-out flow requirements.
- RHR/CS pump required NPSH is taken at a flowrate above that achievable based on system resistance.
- The hydraulic model was based on a Unit 1 model which is assumed to also be applicable to Unit 2. This assumption is supported by:
    1. Similar ECCS/CS pump hydraulic capability.
    2. The most limiting pump NPSH required value was used for the acceptance criteria.
    3. The overall system configuration/resistance and flowrates are similar, with the exception of the 2B CS Heat Exchanger (HX). The 2B HX has spray flow on the shell side, such that the overall resistance coefficient is lower. The B train CS flow model used the lower resistance coefficient for the 2B CS HX to conservatively model higher flow rate.
    4. Suction piping configuration differences and resultant losses are judged to be insignificant.

ECCS Sump Pool Temperature Assumptions
See the response to RAI #11 of Enclosure 1 for the model and assumptions used in generating this temperature profile.

ECCS Sump Pool Minimum Water Level Assumptions
See the response to RAI #41 of Enclosure 1 for the model and assumptions used in generating the minimum sump pool water level.

3(g)(3) Provide the basis for the required NPSH values, e.g., three percent head drop or other criterion.

McGuire Response:
The required NPSH values for the ECCS/CS pumps are taken from the applicable pump head curves. In determining required NPSH values, flowrates beyond the limiting flow rates for the hydraulic model were conservatively used.

3(g)(4) Describe how friction and other flow losses are accounted for.

McGuire Response:
The methodology and assumptions used for the hydraulic modeling of the modified McGuire ECCS sump strainer are located in Section 3(f), item 3(f)(9). For the remainder of the connected ECCS/CS piping systems, hydraulic models are generated using standard methodologies which apply appropriate resistance coefficients and friction factors (e.g., the ECCS/CS NPSH calculations include a representative piping roughness factor based on commercial steel piping).

3(g)(5) Describe the system response scenarios for LBLOCA and SBLOCAs.

McGuire Response:
Upon initiation of a LBLOCA or SBLOCA, the ECCS/CS systems respond as described following:

Large Break LOCA
The ECCS will automatically start and align for Injection Phase upon receipt of a Safety Injection signal. The CSS will automatically start on high Containment Pressure. During the Injection Phase, water is taken from the Refueling Water Storage Tank and injected into the RCS through the cold legs. Dependent upon break size, the Cold Leg Accumulator tanks will also discharge into the RCS.

Upon reaching the Refueling Water Storage Tank (FWST) low level setpoint, the Cold Leg Recirculation Phase is entered, where the RHR pumps and CSS pumps take suction from the containment ECCS sump pools. The RHR pumps then supply flow to the SI and Charging pump inlets. Only one train of RHR is required for the ECCS sump pool recirculation alignment.

To help control containment pressure after the ice beds have melted, one train of auxiliary containment spray from the RHR System is also initiated.

At approximately 9 hours into the accident, the Hot Leg Recirculation Phase is entered where the ECCS pumps supply flow to both Hot and Cold Leg injection lines (SI to the RCS Hot Legs and RHR to the RCS Cold Legs). SI pump flow to the cold legs is isolated for hot leg recirculation.

Small Break LOCA
For SBLOCAs, the break size determines ECCS/CS involvement. If the break is small, Charging System flow will provide make-up from the FWST until the plant is stabilized. CSS pumps will likely not be needed for control of containment pressure, and recirculation from the ECCS sump pool would also not be expected. For larger SBLOCA scenarios, SI will also initiate, most likely on a low RCS pressure signal, and take flow from the FWST. For breaks of this size the ice condenser melt water will provide ECCS sump inventory, along with the RCS break flow and FWST contribution. ECCS recirculation will be initiated only when the appropriate ECCS sump pool level setpoint is reached. CS will be initiated only if necessary, taking suction from the ECCS sump pool when the appropriate (higher) ECCS sump pool level setpoint is reached.

3(g)(6) Describe the operational status for each ECCS and CSS pump before and after the initiation of recirculation.

McGuire Response:
During a LBLOCA, prior to the initiation of ECCS sump pool recirculation and during the Cold Leg Injection mode, the ECCS and CSS pumps will be operating as follows:

- Both RHR pumps will be running, aligned to the FWST.
- Both CS pumps will be running, aligned to the FWST.
- Both SI pumps will be running, aligned to the FWST.
- Both Charging pumps will be running, aligned to the FWST.

ECCS sump recirculation mode is initiated from decreasing FWST level indication. As the initiation of ECCS sump pool recirculation approaches, the ECCS and CSS pumps are realigned and operate as follows:

- The ECCS sump valves automatically open at FWST Low Level Setpoint aligning to RHR suction. The RHR suction valves to the FWST are manually closed. RHR pumps remain running.
- Charging and SI pumps are manually aligned to the RHR pump discharge with both pumps running. Charging/SI pump suction from the FWST is manually isolated.
- At the FWST low-low level alarm, the CS pumps are manually secured. The CS pump suction is realigned to the ECCS sump and both CS pumps are restarted.

3(g)(7) Describe the single failure assumptions relevant to pump operation and sump performance.

McGuire Response:
The McGuire ECCS components are designed such that the Charging pumps, SI pumps, RHR pumps, and CS pumps, together with their associated valves and piping, will assure adequate core cooling in the event of a Design Basis Loss of Coolant Accident.

For ECCS systems described below, the "short term" ends when the ECCS is placed in ECCS recirculation mode.

Charging pumps
The ECCS portion of the McGuire Charging System has two redundant trains of active and passive safety-related equipment that meet single failure criteria. This equipment is designed to tolerate an active failure during the short term or a passive failure in the long term following a Design Basis Accident.

Safety Injection pumps
With two redundant trains per Unit, the McGuire SI system is designed to tolerate a single active failure during the short term or an active or passive failure during the long term following a Design Basis Accident.

Residual Heat Removal pumps
The McGuire RHR system is designed to meet single failure criteria, with two redundant trains per unit. The RHR system is designed to tolerate a single active failure during the short-term or a passive failure during the long term following a Design Basis Accident.

Containment Spray pumps
The McGuire Containment Spray System, including required auxiliary systems, is designed such that it will tolerate a single active failure during the injection phase or a single active or passive failure during the recirculation phase following a

Reactor Coolant System failure, without loss of its protective function. System active components are redundant. System piping located within the Containment is redundant and separated in arrangement unless fully protected from consequential damage which may follow any Reactor Coolant System pipe failure. Emergency power system arrangements assure the proper functioning of the Containment Spray System during loss-of-power conditions.

ECCS Sump Strainer
At McGuire, a single, shared (non-redundant) strainer is utilized. The need to maintain two physically separated ECCS containment sumps or ECCS/CSS train separation within the same sump is unnecessary.

This is described in Duke letter to USNRC dated March 8, 2007 "License Amendment Request Revising McGuire Units 1 and 2 Updated Final Safety Analysis Report Commitments to USNRC Regulatory Guide 1.82, Revision 0, "Sumps For Emergency Core Cooling and Containment Spray Systems" and Revising McGuire Units 1 and 2 Technical Specification Surveillance Requirement (SR) 3.5.2.8 and Associated Bases.

3(g)(8) Describe how the containment sump water level is determined.

McGuire Response:
Two containment water level indicator channels provide the Control Room with ECCS sump water level indication. Additionally, two level switches are provided to annunciate when realignment to the ECCS sump is allowable for the ECCS and CS pumps.

3(g)(9) Provide assumptions that are included in the analysis to ensure a minimum (conservative) water level is used in determining NPSH margin.

McGuire Response:
As noted in item 3(g)(2) above, available NPSH is determined from the floor elevation of the McGuire ECCS sump (elevation 725' + 0") instead of the available water level. Using the floor elevation of the ECCS sump is a conservative assumption in calculating NPSH margin.

3(g)(10) Describe whether and how the following volumes have been accounted for in pool level calculations: empty spray pipe, water droplets, condensation and holdup on horizontal and vertical surfaces. If any are not accounted for, explain why.

McGuire Response:
A SBLOCA is the limiting case for pool minimum volume calculations. In determining applicable inventory penalties for SBLOCAs, the following diversions were accounted for:

- Incore Room Diversion
- Volume Control Tank (VCT) Diversion
- Pressurizer Relief Tank (PRT) Diversion
- Lower Containment Ventilation (VL) Diversion

The following volumes were accounted for when determining Upper Containment Holdup Volume:

- Refueling Canal Holdup
- Refueling Deck Holdup (3-inch curb around the refueling canal)
- CS System Piping Volume
- Airborne spray volume (droplets) in Upper Containment
- Water held up in containment draining down walls

3(g)(11) Provide assumptions (and their bases) as to what equipment will displace water resulting in higher pool level.

McGuire Response:
Various types of large robust miscellaneous equipment (e.g., tanks, housings, piping, base plates, rupture restraints, and supports) were assumed to displace water in the determination of ECCS sump volume. Smaller miscellaneous equipment (e.g., small bore piping, cable trays, transformers, and tubing) were conservatively excluded. The ECCS sump strainer is also included as a volume displacer. In addition, the calculation conservatively does not take water displacement credit for insulation around pipes.

3(g)(12) Provide assumptions (and their bases) as to what water sources provide pool volume and how much volume is from each source.

McGuire Response:
The following conservative initial condition assumptions are made in determining the volume of water available for the ECCS sump inventory for any break size inside Containment:

- Refueling Water Storage Tank (FWST): The credited volume for the FWST is the Technical Specification minimum allowable volume. Emergency Procedure guidance directs that ECCS pumps be realigned to recirculation mode at the FWST low-low level indication. This level is error-adjusted upward to conservatively reflect maximum remaining tank volume and minimize injected volume.
- Reactor Coolant System: The initial Reactor Coolant Hot Full Power Mass is converted to the Reactor Coolant Mass at 200°F and 300 psia for break conditions.
- Ice Condenser Ice Bed Inventory: The ice bed total mass is assumed to be at the technical specification minimum.
- Cold Leg Accumulators: For larger break sizes, the Technical Specification nominal inventory volume in the Cold Leg Accumulators is assumed to discharge into the RCS.

3(g)(13) If credit is taken for containment accident pressure in determining available NPSH, provide description of the calculation of containment accident pressure used in determining the available NPSH.

McGuire Response:
No credit is taken for containment accident pressure in the McGuire ECCS/CS pump NPSH calculations.

3(g)(14) Provide assumptions made which minimize the containment accident pressure and maximize the sump water temperature.

McGuire Response:
The following significant analytical conditions related to containment accident pressure and temperature response are assumed at the onset of a postulated LBLOCA event:

- Containment pressure is assumed to be atmospheric. No credit is taken for containment accident pressure in the McGuire ECCS/CS pump NPSH calculations.
- FWST water inventory temperature is assumed to be at the technical specification maximum.
- FWST inventory is assumed to be at its technical specification minimum.
- Nuclear Service Water (ultimate heat sink) temperature is assumed to be conservatively high.
- Ice bed inventory is assumed to be at the technical specification minimum.

- Minimum safeguards are assumed

3(g)(15) Specify whether the containment accident pressure is set at the vapor pressure corresponding to the sump liquid temperature.

McGuire Response:
No credit is taken in ECCS/CS pump NPSH calculations for increased containment pressure during an accident. The vapor pressure input to the available NPSH hydraulic model for the ECCS/CS pumps is taken at the sump pool maximum temperature of 190°F at atmospheric pressure.

3(g)(16) Provide the NPSH margin results for pumps taking suction from the sump in recirculation mode.

McGuire Response:
The limiting NPSH margin for the RHR/CS pumps taking suction from the ECCS sump pool in recirculation mode is shown in Table 3G16-1.

The limiting NPSH available values shown in the Table assume two-train operation to maximize the suction flow path head losses; and no ECCS sump strainer differential pressure losses. Strainer differential pressure losses generally are time dependent and largely offset by vapor pressure reduction and sump pool level increase over time. The refined debris-loaded head loss predicted at the ECCS sump strainer, including chemical effects, is discussed in Section 3(f) of Enclosure 2.

Table 3G16-1

McGuire RHR / CS Pump NPSH Margins

	NPSH Required (ft-water)	NPSH Available (ft-water)	NPSH Margin (ft-water)
CS Pumps	19	> 29	> 10
RHR Pumps	19	> 33	>14

As described in the response to RAI #12 of Enclosure 1, the total ECCS sump strainer head loss for the McGuire strainers will be based on the results of the Integrated Prototype Test (IPT). The IPT is more fully described in the response to RAI #11 of Enclosure 1. Upon completion of the IPT documentation, a refined debris load head loss calculation will incorporate any added consequence of tested chemical effects. This is a commitment identified in Duke letter dated

November 6, 2007 "Request for Extension of Completion Dates for McGuire Units 1 and 2 Corrective Actions Required by NRC Generic Letter (GL) 2004-02".

Final limiting NPSH margins for the McGuire RHR/CS pumps will be determined based on the refined debris-loaded head loss calculation results and reported in the response to RAI #12 of Enclosure 1. Duke expects to have this documentation and to supplement the response to RAI #12 by April 30, 2008.

3(h) Coatings Evaluation

The objective of the coatings evaluation section is to determine the plant-specific ZOI and debris characteristics for coatings for use in determining the eventual contribution of coatings to overall head loss at the sump screen.

3(h)(1) Provide a summary of type(s) of coating systems used in containment, e.g., Carboline CZ 11 Inorganic Zinc primer, Ameron 90 epoxy finish coat.

McGuire Response:
The qualified coatings systems for the concrete surfaces and the steel structures and components inside containment consist of:

- Carboline 890
- Valspar 76-Series High Build
- Valspar 89-C-3-00
- Valspar 13-F-12KR-00 MZ #7 Primer
- Valspar 89-Series Epoxy
- Carbozinc 11 SG Primer

The unqualified coatings inside containment consist of:

- Epoxy
- Alkyd Enamel
- Cold galvanizing

3(h)(2) Describe and provide bases for assumptions made in post-LOCA paint debris transport analysis.

McGuire Response:
The following assumptions relating to failed coatings debris are made for the debris transport analysis:

- It is assumed that the settling velocity of fine debris (including paint particulate) can be calculated using Stokes' Law. This is a reasonable assumption since the particulate debris is generally spherical and would settle slowly (within the applicability of Stokes' Law).
- The unqualified coatings in containment are assumed to be uniformly distributed in the containment pool at the beginning of recirculation. This is a reasonable assumption since the unqualified coatings are scattered in

small quantities throughout containment. The assumption for distribution is not significant since particulate is so readily transported.

- The qualified coatings are assumed to be Carboline 890 since this system has the largest qualified coating thickness.
- In accordance with the NRC SER of NEI 04-07 guidance, all unqualified coatings in containment are assumed to fail, as well as all qualified coatings within the break ZOI.
- It is assumed that failed coatings in upper containment are washed down by containment sprays. 100% of paint fines located in the ice condenser and upper containment are assumed to washdown and transport to the strainer.
- All failed coatings (including coatings inside the break ZOI and unqualified coatings outside the break ZOI), are conservatively assumed to be particulate. No coating debris in the size/shape of paint fines or paint chips is considered.

3(h)(3) Discuss suction strainer head loss testing performed as it relates to both qualified and unqualified coatings and what surrogate material was used to simulate coatings debris.

McGuire Response:
Two sets of debris head loss tests were performed for the McGuire ECCS sump strainer design. A Top-hat Array Test, utilizing horizontally positioned top-hat strainer modules in a 2 × 3 arrangement, was conducted to determine the susceptibility of the top-hats to the thin-bed effect and to determine the head loss correlation using representative debris loading challenges, including particulates. This testing is also described in the response to RAI #40 of Enclosure 1. A surrogate, SIL-CO-SIL™ 53 Ground Silica was used for the failed qualified and unqualified coatings in the Top-hat Array Test.

Subsequently, an Integrated Prototype Test was performed utilizing one horizontally positioned top-hat module, to determine actual head loss during the ECCS mission time using refined debris loading, including particulates, and chemical effects. This testing is described further in the response to RAI #11 of Enclosure 1. For this test, silica oxide flour (1250 Novacite®) represented the failed qualified and unqualified coatings. No surrogate for failed inorganic zinc coatings was used in this test, since McGuire contains the bounding particulate load for the Duke ice condenser plants and has no inorganic zinc coatings.

In the containment sump pool, the particulate material will occupy a certain volume in the fibrous debris space resulting in increased resistance to flow and higher head loss. The surrogate material volume was therefore adjusted in both of these tests to match the volume of the failed coatings particulate for coatings that are less dense than the surrogate.

3(h)(4) Provide bases for the choice of surrogates.

McGuire Response:
SIL-CO-SIL™ 53 Ground Silica is the surrogate used to represent the failed qualified and unqualified coatings at McGuire in the Top-hat Array Test. The ground silica material specific gravity is 2.65, which corresponds to a density of 165 lb/ft^3; epoxy and alkyd coatings densities range from 94 lb/ft^3 to 98 lb/ft^3 per NEI 04-07 guidance. The ground silica is a spherical particulate ranging in size from just under 1 micron to approximately 100 microns. The majority of the failed coatings are on the order of 10 microns in size or greater. Since a significant portion of the ground silica material is less than 10 microns, the ground silica would tend to produce a debris bed with a lower porosity and higher surface-to-volume ratio than a debris bed comprised of failed coating material alone. Thus, the use of ground silica as a surrogate for failed coating debris in the Top-hat Array Test is conservative.

Silica oxide flour (1250 Novacite®) represented the failed qualified and unqualified coatings in the Integrated Prototype Test. This particulate debris surrogate material was selected based on chemical reactivity and a comparison of the microscopic densities of the material. Epoxy and alkyd coatings densities range from 94 lb/ft^3 to 98 lb/ft^3 per NEI 04-07 guidance[15]; silica oxide flour has a material specific gravity of 2.65, corresponding to a microscopic density of 165 lb/ft^3. The particle size for failed epoxy and alkyd coatings is assumed to be 10 microns. The silica oxide flour surrogate material is a spherical particulate where 99% is less than 45 microns in diameter and 69% is less than 10 microns.

3(h)(5) Describe and provide bases for coatings debris generation assumptions. For example, describe how the quantity of paint debris was determined based on ZOI size for qualified and unqualified coatings.

McGuire Response:
When considering the quantification of post-accident coatings debris generation, the guidelines presented in the NRC SER of NEI 04-07 were followed. Per NEI 04-07, qualified and unqualified coatings within the ZOI are assumed to fail as a result of impingement and post-accident environmental conditions. Qualified coatings outside the ZOI are assumed to remain intact and adhered to their substrate.

A CAD model of containment is used to determine the area of qualified coatings within the ZOI for each break in consideration. The volume of qualified coatings within the ZOI is calculated based on a maximum of 12 mils thick for concrete floors and walls and a maximum of 11 mils thick for steel surfaces.

The following assumptions are made in the McGuire debris generation evaluation related to coatings:

- Per NEI 04-07 guidance, all unqualified coatings in containment are assumed to fail as 10 micron spheres during the HELB; the containment walkdown reports are used as the basis for the quantity of unqualified coatings.
- Qualified coatings in the break ZOI are also assumed to fail as 10 micron spheres. The walkdown report and coatings specifications were used to determine the type, thickness, and number of coats applied.
- Qualified coatings are assumed to fail within a 5D ZOI as defined by the WCAP-16568-P methodology, in lieu of the 10D ZOI defined by NRC SER of NEI 04-07.
- Unqualified epoxy coatings debris quantities and transport metrics are refined based on analysis of OEM coatings performed by EPRI. It is assumed that Duke-applied coatings inside containment are similar to the manufacturer-applied coatings used in the analysis. Unqualified alkyd coatings debris and qualified coatings debris are not affected by this refinement.
- The qualified coatings are assumed to be Carboline 890 since this system has the largest qualified coating thickness.

Other assumptions related to the transport of failed coatings debris are identified in the response to item 3(h)(2) above.

Table 3H5-1 below shows the ZOI radius and destruction pressure for McGuire qualified coatings.

Table 3H5-1

ZOI Radius for McGuire Qualified Coatings

Debris Type	Destruction Pressure (psi)	ZOI Radius/Break Diameter (L/D)
Protective Coatings (epoxy and epoxy-phenolic paints)	Not measured**	5.0

** The approach taken for testing was to position the test coupon a distance from the jet and observe the coatings performance. If no degradation of coatings was observed, a ZOI was calculated using the ANSI/ANS 58.2-1988 jet expansion model. A specific destruction pressure was not measured.

Postulated qualified and unqualified coatings debris quantities are located in the response to item 3(h)(6) below.

3(h)(6) Describe what debris characteristics were assumed, i.e., chips, particulate, size distribution and provide bases for the assumptions.

McGuire Response:
All failed coatings (including coatings inside the break ZOI and unqualified coatings outside the break ZOI), are conservatively assumed to be particulate. No coating debris in the size/shape of paint fines or paint chips is considered.

The NEI 04-07 guidance report and companion SER are followed for the coatings debris evaluation, and conservatively assume that the coatings will all fail as highly transportable 10 micron spherical particles. The qualified coating materials at McGuire are a maximum of 12 mils thick for concrete floors and walls and a maximum of 11 mils thick for steel surfaces. It is conservative to assume all of this coating material will erode to pigment-sized particles. Further, qualified coatings are assumed to be Carboline 890 since this system has the largest qualified coating thickness.

The debris characteristics and postulated debris quantities for McGuire qualified and unqualified coatings are shown in Tables 3H6-1 and 3H6-2 below:

Table 3H6-1

McGuire Qualified Coatings Characteristics

Area Within ZOI	Area (ft^2)	Thickness	Analysis Size	Volume (ft^3)	Density (lb/ft^3)	Weight (lb)
Concrete Surfaces	568	12 mils	10 micron	0.57	118	67.3
Steel Surfaces	928	11 mils	10 micron	0.85	118	100.3
Total	1,496	N/A	10 micron	1.42	118	167.6

Table 3H6-2

McGuire Unqualified Coatings Characteristics

Coating Material	Total Area (ft^2)	DFT* (mils)	Volume (ft^3)	Density (lb/ft^3)	Weight** (lb)	Analysis Size
Epoxy	13,917	6	3.8	94	357.1	10 micron
Alkyd Enamel	1,213	1.5	0.16	98	15.7	10 micron
Total	15,130	N/A	3.96	N/A	372.8	10 micron

* DFT: Dry Film Thickness

** As identified in the response to question 3(h)(5) above, unqualified epoxy coatings debris quantities and transport metrics are refined based on analysis of OEM coatings performed by EPRI. Duke has revised the initial statistical assessment and incorporated a more conservative unqualified particulate refinement based upon applying a 2 standard deviation correction from the mean. It is assumed that Duke-applied coatings inside containment are similar to the manufacturer-applied coatings used in the analysis. Unqualified alkyd coatings debris and qualified coatings debris are not affected by this refinement.

3(h)(7) Describe any ongoing containment coating condition assessment program.

McGuire Response:

The comprehensive Duke Energy Corporation Containment Coatings Assessment Program in effect at McGuire is used to identify degraded qualified/acceptable coatings and determine the amount of debris that will result from these coatings. This program also ensures that qualified/acceptable coatings remain in compliance with plant licensing requirements for design-basis accident (DBA) performance.

This assessment program is discussed in detail in the response to RAI #25 of Enclosure 1.

3(i) Debris Source Term Refinements

The objective of the debris source term section is to identify any significant design and operational measures taken to control or reduce the plant debris source term to prevent potential adverse effects on the ECCS and CSS recirculation functions.

Provide the information requested in GL 04-02 Requested Information Item 2(f) regarding programmatic controls taken to limit debris sources in containment.

GL 2004-02 Requested Information Item 2(f)
A description of the existing or planned programmatic controls that will ensure that potential sources of debris introduced into containment (e.g., insulations, signs, coatings, and foreign materials) will be assessed for potential adverse effects on the ECCS and CSS recirculation functions. Addressees may reference their responses to GL 98-04, "Potential for Degradation of the Emergency Core Cooling System and the Containment Spray System after a Loss-of-Coolant Accident Because of Construction and Protective Coating Deficiencies and Foreign Material in Containment," to the extent that their responses address these specific foreign material control issues.

In responding to GL 2004-02 Requested Information item 2(f), provide the following:

3(i)(1) A summary of the containment housekeeping programmatic controls in place to control or reduce the latent debris burden. Specifically for RMI/low-fiber plants, provide a description of programmatic controls to maintain the latent debris fiber source term into the future to ensure assumptions and conclusions regarding inability to form a thin bed of fibrous debris remain valid.

McGuire Response:
McGuire is not considered a low fiber plant, so the latent debris (particulate) source term is not dominant. The control of latent debris and miscellaneous latent debris (tags, labels, etc.) is still important and essential, and McGuire has implemented programmatic controls to ensure that potential sources of debris that may be introduced into containment will be assessed for adverse effects on the ECCS and Containment Spray recirculation functions.

These programmatic controls include:

- Coatings Program:
  Duke has established controls for procurement, application, and maintenance of Duke-applied, Service Level 1 protective coatings used inside containment. Further discussion regarding Duke's Containment Coatings Assessment Program is located in the response to RAI #25 of Enclosure 1.

- Containment Housekeeping/Materiel Condition:
  Extensive containment cleaning is performed during each refueling outage using water spray, vacuuming and hand wiping. Localized wash downs are performed as needed and visual inspections are performed on the remaining areas of containment. Foreign material is removed as necessary. Upgrades to existing foreign material control procedures require material accountability logs to be maintained in Modes 1 through 4 for items carried into and out of containment. These controls are implemented using administrative procedures.

- The plant labeling process has been enhanced to require that any additional labels or signs placed inside containment be evaluated to ensure that the design basis for transportable debris is not invalidated.

- McGuire Technical Specification Surveillance Requirement (SR):
  McGuire Technical Specification Surveillance Requirement 3.5.2.8 requires that the ECCS sump be visually inspected to verify there are no restrictions as a result of debris, and no evidence of structural distress or abnormal corrosion present prior to declaring the ECCS sump operable. A visual inspection of containment is performed to ensure no loose material is present which could be transported to the Containment Sump and cause restriction of the ECCS pump suction during accident conditions prior to the transition from Mode 5 to Mode 4 operations. When these inspections are performed, major outage work is complete, and any remaining loose material in containment must be logged and tracked in accordance with station procedures for control and accountability. If any debris, damage or deficiency were to be discovered during the inspection, station processes require entry into the corrective action program, with the requisite investigation and implementation of appropriate corrective action prior to the transition from Mode 5 to Mode 4.

- Additionally, McGuire Selected Licensee Commitment 16.6.1 ensures that a visual inspection is performed to identify any loose debris inside containment and ensure it is removed prior to establishing containment integrity and following entries made after containment integrity is established.

- Modification Process:
  Duke's modification process currently includes an administrative procedure that directs the design and implementation of engineering changes in the plant. This procedure directs that engineering changes be evaluated for system interactions. As part of this evaluation, there is direction to include consideration of any potential adverse effect with regard to debris sources and/or debris transport paths associated with the containment sump.

3(i)(2) A summary of the foreign material exclusion programmatic controls in place to control the introduction of foreign material into the containment.

McGuire Response:
As noted above, visual inspections are performed in containment and foreign material is removed as necessary. Upgraded foreign material control procedures require material accountability logs to be maintained in Modes 1 through 4 for items carried into and out of containment. These controls are implemented using administrative procedures.

The plant labeling process has been enhanced to require that any additional labels or signs placed inside containment be evaluated to ensure that the design basis for transportable debris is not invalidated.

3(i)(3) A description of how permanent plant changes inside containment are programmatically controlled so as to not change the analytical assumptions and numerical inputs of the licensee analyses supporting the conclusion that the reactor plant remains in compliance with 10 CFR 50.46 and related regulatory requirements.

McGuire Response:
Duke's modification process currently includes an administrative procedure that directs the design and implementation of engineering changes in the plant. This procedure directs that engineering changes be evaluated for system interactions. As part of this evaluation, there is direction to include consideration of any potential adverse effect with regard to debris sources and/or debris transport paths associated with the containment sump.

3(i)(4) A description of how maintenance activities including associated temporary changes are assessed and managed in accordance with the Maintenance Rule, 10 CFR 50.65.

McGuire Response:
Risk management per 10CFR50.65 a(4) at McGuire is managed programmatically during both innage periods and outage periods, as described following:

Operational Risk Management (Modes 1-3) per 10CFR 50.65 a(4)

To ensure compliance with 10CFR 50.65 a(4), risk assessments are performed prior to conducting any maintenance at McGuire. Maintenance includes all activities traditionally associated with identifying and correcting degraded conditions including corrective maintenance, plant Engineering Changes, and preventive maintenance including surveillance, predictive and preventive activities.

Temporary alterations are maintenance-related activities that do not permanently alter the design or design function of plant structures, systems, or components (SSCs). NEI 96-07, "Guidelines for 10CFR 50.59 Implementation", includes discussion to advise between three distinct but related topics: Maintenance Rule, Maintenance Activities, and Temporary Alterations. Compliance with 10CFR 50.65 a(4), Maintenance Rule, requires any temporary alteration to be evaluated for risk prior to performing the work. Once these alterations are in place, they may exist for ninety days of power operation before they must be considered as potentially being a permanent Engineering Change.

Since the temporary alterations are associated with maintenance activities, no review is required under 10CFR 50.59 unless the measures are expected to remain in place for greater than ninety days of power operation. If, during power operation, the temporary alteration is expected to be in effect for greater than ninety days, the temporary alteration is screened and if necessary evaluation performed under 10CFR 50.59 prior to implementation.

Shutdown Risk Management (Modes 4, 5, 6, and No-Mode) per 10CFR 50.65 a(4)

Consistent with 10CFR 50.65 a(4) requirements for outage periods, McGuire maintenance activities during outages are cognizant of the risk associated with work evolutions, and the out-of-service duration of risk significant components are managed to mitigate risk.

For activities that create temporary alterations such as lifting leads, placing jumpers on terminals, and installing trips and bypasses, the associated equipment is considered to be out of service. Conservatively, the SSC is considered to be unavailable to perform its function and is evaluated as such during the risk assessment.

If an SSC is required to be available with a temporary alteration in place, an evaluation of the effects of the alteration must be performed. Only after evaluation can the SSC be determined to be available with temporary alterations in place.

For activities that install other temporary alterations such as scaffold, lead shielding, and supports, programs are in place to evaluate and control the effects of those alterations.

3(i)(5) If any of the following suggested design and operational refinements given in the guidance report (guidance report, Section 5) and SE (SE, Section 5.1) were used, summarize the application of the refinements.

- **Recent or planned insulation change-outs in the containment which will reduce the debris burden at the sump strainers.**
- **Any actions taken to modify existing insulation (e.g., jacketing or banding) to reduce the debris burden at the sump strainers.**
- **Modifications to equipment or systems conducted to reduce the debris burden at the sump strainers.**
- **Actions taken to modify or improve the containment coatings program.**

<u>McGuire Response:</u>
Change-out of Insulation
While McGuire maintains the strategic option to replace insulation, the change out of insulation in the McGuire containments to reduce the debris burden at the ECCS sump strainers is not necessary to be in full compliance with the requirements of GL 2004-02.

Modify Existing Insulation
As discussed in the response to RAI #35 of Enclosure 1, Microtherm® insulation previously installed on portions of the McGuire Unit 1 and Unit 2 reactor vessel heads was removed and replaced with Reflective Metal Insulation (RMI). The reactor vessel head is not in the area of the limiting break. Debris transport calculations show that RMI (for the limiting break location) will not transport to the containment sump.

Modify Other Equipment or Systems
Electromark® labels have been evaluated as capable of withstanding the limiting break in all areas of containment except inside the crane wall in lower containment, and the miscellaneous latent debris quantification has been adjusted accordingly.

Duke's modification process currently includes an administrative procedure that directs the design and implementation of engineering changes in the plant. This procedure directs that engineering changes be evaluated for system interactions. As part of this evaluation, there is direction to include consideration of any potential adverse effect with regard to debris sources and/or debris transport paths associated with the containment sump.

Modify or Improve Coatings Program
As discussed in detail in the response to RAI #25 of Enclosure 1, a containment coatings condition assessment is conducted during each refueling outage or any other extended outage. The containment coating condition assessment protocol consists of a visual inspection of all readily accessible coated areas by qualified personnel. When degraded coatings are visually identified, the affected areas are documented in accordance with plant procedures. Additional nondestructive and/or destructive examinations are conducted as appropriate to define the extent of the degraded coatings and to enable disposition of the coating deficiency. The guidance contained in EPRI Report 109937 is used as appropriate to disposition areas of degraded coatings when discovered, including:

1. Performance of additional in situ and/or laboratory testing of degraded coatings,
2. Removal and replacement of degraded coatings,
3. Repairing degraded coatings,
4. Mitigation of accident consequences related to failure of degraded coatings,
5. Leaving coating in place based on evaluation of effects of failure (detachment) of the degraded coating on ECCS system performance, and/or
6. Upgrading of indeterminate coatings.

If, after identification, degraded qualified/acceptable coatings will be left in place during plant operation, the degraded qualified/acceptable coatings are assumed to fail and to be available for transport to the ECCS sump. After each containment coatings condition assessment, the quantity listing of degraded coatings is updated, and the revised quantity of degraded coatings is verified to meet the acceptance limit in the ECCS debris source term analysis.

3(j) Screen Modification Package
The objective of the screen modification package section is to provide a basic description of the sump screen modification.

3(j)(1) Provide a description of the major features of the sump screen design modification.

McGuire Response:
The McGuire ECCS sump strainer modification removes the original ECCS containment sump screen and replaces it with a larger strainer assembly developed using NEI 04-07 and other industry guidance. The major features of the strainer design modification include the following:

- The modified strainer assembly is constructed of robust materials and is located both inside and outside the crane wall (see Figure 3J-1).
- The modified strainer designs were expanded to approximately 1700 square feet, which is the largest practical installation in the existing Unit 1 and Unit 2 lower containment area (accounting for strainer submergence requirements).
- The portion of the strainer assembly located Inside the Crane Wall is housed within a stainless steel enclosure constructed using a structural framework with platform grating covering the tops and sides. Enclosure side plating is 14 gage, perforated with 3/32 inch nominal diameter holes, and the enclosure top is solid 14 gage plate.
- The portion of the strainer assembly located outside the crane wall (Pipechase) is covered by a structural framework with platform grating covering the top. No solid plate top or perforated plate enclosure is included.
- Outside the crane wall, the two train-specific ECCS/CSS recirculation lines connect directly to the main waterboxes via 18-inch diameter piping. The two pipechase waterboxes are interconnected to one another via plenums and connected to the Inside the Crane Wall strainer assemblies by 18- inch diameter pipes that pass through crane wall penetrations.
- The strainer assemblies consist of a series of stainless steel tubular modules (top-hats) connected by a plenum to water boxes. The top-hats are constructed from two concentric, rolled perforated plates. The openings in the perforated plate are 3/32 inch diameter nominal. Sandwiched between the concentric tubes of each top-hat module is a bypass eliminator, fabricated from fine knitted wire. This component is designed to further filter fine entrained debris that has already penetrated the perforated top-hat exterior.

- Horizontal vortex suppressors are installed above the top-hat assemblies located in the pipechase. Vortex suppression for ICW strainer assemblies is provided by the solid top deck of the enclosure.
- The McGuire modified ECCS sump strainer assembly and enclosure are nuclear safety-related and designed to withstand safe shutdown earthquake loadings and protected from tornado missiles by virtue of being located within the Containment Building which, in turn, is protected by the seismically designed Reactor Building. The structures are passive assemblies (i.e., no moving parts) qualified for the design environmental conditions of the sump. These structures are designed for the containment sub-compartment differential pressures from the limiting case pressurizer surge line pipe break.

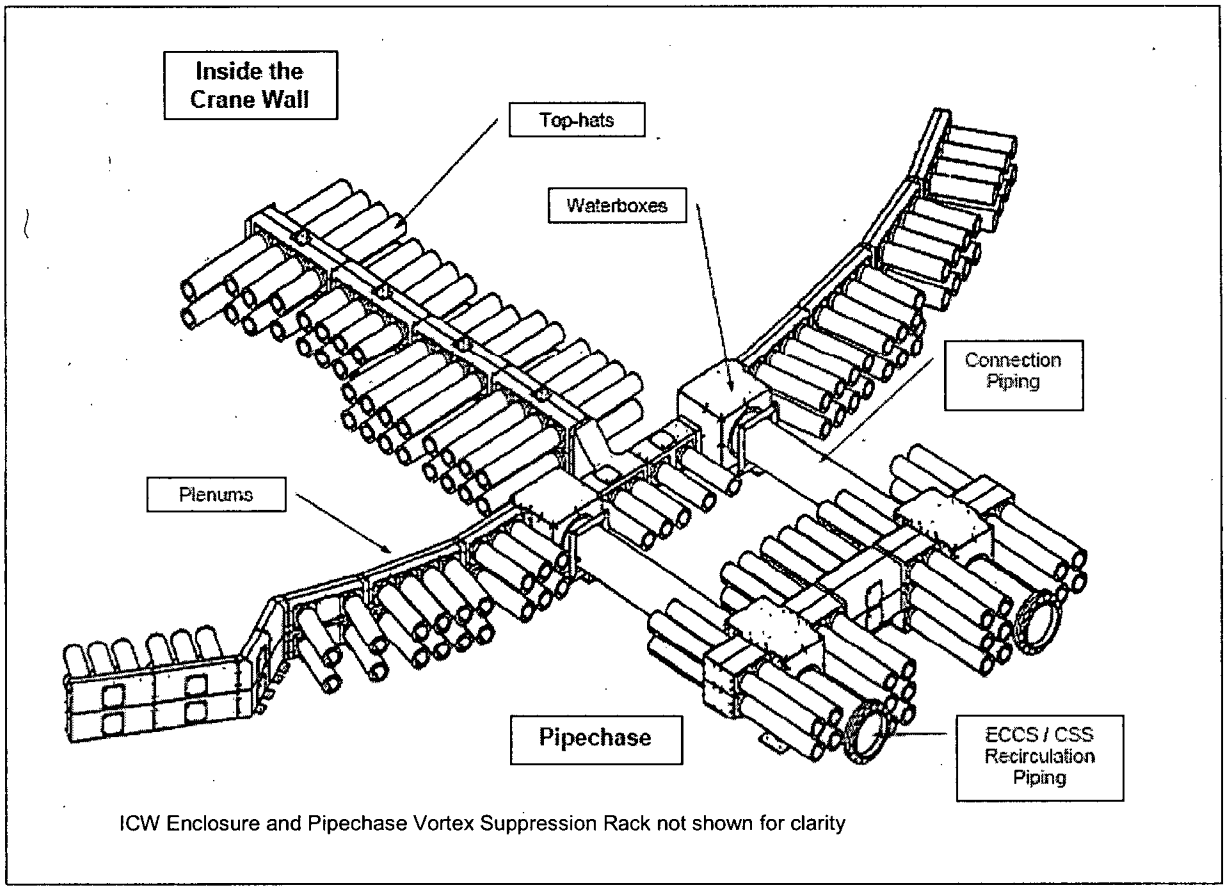


Figure 3J-1

McGuire Modified ECCS Sump Strainer

3(j)(2) Provide a list of any modifications, such as reroute of piping and other components, relocation of supports, addition of whip restraints and missile shields, etc., necessitated by the sump strainer modifications.

McGuire Response:
A summary of noteworthy modifications necessitated by the McGuire Unit 1 and Unit 2 modified ECCS sump strainer installations appears below.

1. Associated with installation of modified ECCS sump strainer on Unit 1
   - Added a whip restraint / jet barrier for the RHR piping connected to the RCS to protect strainer components.
   - The "B" Train Containment Purge Ventilation Unit was removed. This removal was required to accommodate the extension of the strainer.
   - Rerouting of 1-inch Liquid Waste piping.
   - Rerouting of 6-inch Component Cooling piping.
   - Perforated cover plate located at the bottom drain of the refueling canal removed.

2. Associated with installation of modified ECCS sump strainer on Unit 2 (two Phases). Phase 1 installation is complete; Phase 2 will be installed in spring 2008.
   - Modification Phase 2 will add a whip restraint / jet barrier for the RHR piping connected to the RCS to protect strainer components
   - The "B" Train Containment Purge Ventilation Unit was removed. This removal was required to accommodate the extension of the strainer
   - Perforated cover plate located at the bottom drain of the refueling canal removed

3(k) Sump Structural Analysis

The objective of the sump structural analysis section is to verify the structural adequacy of the sump strainer including seismic loads and loads due to differential pressure, missiles, and jet forces.

Provide the information requested in GL 2004-02 Requested Information Item 2(d)(vii).

GL 2004-02 Requested Information Item 2(d)(vii)
Verification that the strength of the trash racks is adequate to protect the debris screens from missiles and other large debris. The submittal should also provide verification that the trash racks and sump screens are capable of withstanding the loads imposed by expanding jets, missiles, the accumulation of debris, and pressure differentials caused by post-LOCA blockage under flow conditions.

3(k)(1) Summarize the design inputs, design codes, loads, and load combinations utilized for the sump strainer structural analysis.

McGuire Response:
Table 3K1-1 below shows the design inputs for the McGuire modified ECCS sump strainer structural calculations, including the top-hats, the strainer sections Inside the Crane Wall and in the Pipechase, the Inside the Crane Wall Strainer Enclosure, and the Pipechase Vortex Suppression Rack.

Table 3K1-1

Design Inputs/Loads for McGuire ECCS Sump Strainer

	Design Input	Top-hat module*	ICW / Pipechase Sections	ICW Enclosure	Pipechase Vortex Supp. Rack
	Temperature	300 °F	300 °F	250 °F	250 °F
	Differential Pressure	10 psid	7 psid	4 psid solid plate, 2.69 psid perforated	NA
	Dead Weight	0.29 lb/in^3	0.29 lb/in^3	0.29 lb/in^3	0.29 lb/in^3
	Live Load	-	-	100 psf	100 psf
	Misc. Load (Cable Tray/Conduit)	-	-	75 lb	-
Seismic	ZPA Frequency	20 Hz	20 Hz	20 Hz	20 Hz
Seismic	Damping	2%	2%	2%	2%
Seismic	Max SSE Horizontal Acc.	0.53 g	0.53 g	0.53 g	0.53 g
Seismic	Max SSE Vertical Acc.	0.35 g	0.35 g	0.35 g	0.35 g

* Bounding top-hat length is 45 inches for structural analysis

Table 3K1-2 below shows the design load combinations for the Inside the Crane Wall and Pipechase Sections, the Inside the Crane Wall Enclosure, and the Pipechase Vortex Suppression Rack. For this table, "F_s" represents the allowable stress in steel as specified in AISC Part 1.

Table 3K1-2

Load Combinations for McGuire ECCS Sump Strainer

Load Combinations (ICW & Pipechase Sections, ICW Enclosure, Pipechase Vortex Suppression Rack)	
Load Case 1	DL (Dead Load) + CL (Construction Load) = Fs
Load Case 2	DL + OL (Normal Operating Load) + Pa (Accident Differential Pressure) = Fs
Load Case 3	Not used
Load Case 4	DL + OL + OBE = Fs
Load Case 5	DL + OL + SSE = 1.5 Fs
Load Case 6	DL + OL + SSE + Ta (Accident Thermal Load) = 1.5 Fs
Load Case 7	DL + OL + SSE + Pa +Y (Pipe Rupture) = 1.5 Fs

The load combination used for the Top-hat structural calculations is Dead Weight + SSE (including hydrodynamic mass) + Differential Pressure.

The AISC 9th edition is used to qualify all of the components of the McGuire ECCS Sump strainer except for stainless steel studs/bolts, which are qualified per ASME Section III, Division 1, NF-3324.6. Welds for stainless steel material were qualified per AWS D1.6.

3(k)(2) Summarize the structural qualification results and design margins for the various components of the sump strainer structural assembly.

McGuire Response:
Results of the structural analysis concluded that the design of the McGuire modified ECCS sump strainer, including the Top-hats, the sections Inside the Crane Wall and in the Pipechase (including the connector piping and supports), the Inside the Crane Wall enclosure, and the Pipechase Vortex Suppression Rack, meets all AISC, AWS, and ASME code allowable stresses.

3(k)(3) Summarize the evaluations performed for dynamic effects such as pipe whip, jet impingement, and missile impacts associated with high-energy line breaks (as applicable).

McGuire Response:
The response to RAI #31 of Enclosure 1 addressed the evaluation of dynamic effects on the McGuire modified ECCS sump strainer. The response is repeated here for the convenience of the reader.

Postulated high energy pipe breaks which could potentially interact with the modified ECCS containment sump strainer were evaluated in accordance with McGuire's current licensing basis as follows:

a. High energy Pipe Rupture composite drawings were reviewed to identify any postulated breaks in close proximity to the modified ECCS sump strainer assembly and associated enclosure. Postulated high energy break locations, for the purpose of selecting rupture restraints, incorporated Leak Before Break criteria.

b. Postulated breaks were evaluated to determine if the modified ECCS containment sump strainer and associated enclosure were within the target zone of pipe whip or jet impingement.

Per the above methodology, one interaction per Unit at McGuire was identified based upon the new locations of the modified strainer assemblies.

Regulatory commitments were made to install pipe rupture restraints on the Residual Heat Removal System of each Unit. The required rupture restraint has been installed on McGuire Unit 1; the required rupture restraint will be installed on Unit 2 in spring 2008.

3(k)(4) If a backflushing strategy is credited, provide a summary statement regarding the sump strainer structural analysis considering reverse flow.

McGuire Response:
As identified in the response to RAI #33 of Enclosure 1, the use of backflushing (or other active mitigative strategies) was not considered feasible for the McGuire modified ECCS strainer design.

3(l) Upstream Effects

The objective of the upstream effects assessment is to evaluate the flowpaths upstream of the containment sump for holdup of inventory which could reduce flow to and possibly starve the sump.

Provide a summary of the upstream effects evaluation including the information requested in GL 2004-02 Requested Information Item 2(d)(iv).

GL 2004-02 Requested Information Item 2(d)(iv)
The basis for concluding that the water inventory required to ensure adequate ECCS or CSS recirculation would not be held up or diverted by debris blockage at choke-points in containment recirculation sump return flowpaths.

3(l)(1) Summarize the evaluation of the flow paths from the postulated break locations and containment spray washdown to identify potential choke points in the flow field upstream of the sump.

McGuire Response:
The evaluation of post-accident ECCS sump inventory holdup in the McGuire containments includes physical diversions (e.g., curbs and filled CS piping) as well as potential debris blockage. The minimum ECCS sump pool level to ensure strainer submergence is discussed in detail in the response to RAI #41 of Enclosure 1, including the assumptions for lost inventory due to physical diversions. The potential loss of ECCS sump inventory due to debris blockage is discussed here.

The lower containment at McGuire is basically made up of two compartments – the area inside the Crane Wall and the Pipechase. These two areas are connected at lower elevations by a number of crane wall penetrations on each Unit, ranging in diameter up to 12 inches. Many of these penetrations are above the floor. Although it is possible for some of these penetrations to clog with debris, it is unlikely that a sufficient number of the penetrations would become clogged sufficiently to create a situation where the ECCS sump could be starved. The computational fluid dynamics (CFD) model used for the evaluation of debris transport (discussed in detail in Section 3(e) of Enclosure 2) provides the basis for this engineering judgment.

Other potential choke points include the ice condenser drain lines and the refueling canal drains. McGuire has a total of twenty 12-inch ice condenser drain lines for draining the melting ice. If one of these drains were to become clogged, the water would flow to the other drains. It is not likely that all 20 drains would become sufficiently clogged with debris to keep the water from flowing to the containment sump pool. The refueling canal in each Unit has six 8-inch drains that are open during operation. Four of the drains discharge inside the crane wall, and the other two discharge into the pipe chase. The plant was designed so that the majority of the upper containment spray water flows to lower containment through these six drains. Given the size of these drains and the debris postulated to be washed down with the sprays (latent debris, paint chips and/or particulate, and possibly a small quantity of LOCA generated fines blown past the ice baskets) these drains are not likely to become clogged. Finally, the McGuire debris generation calculation does not postulate significant amounts of debris being generated in upper containment, since this area is outside the limiting break zone of influence.

3(I)(2) Summarize measures taken to mitigate potential choke points.

McGuire Response:
McGuire Technical Specification Surveillance Requirement (SR) 3.5.2.8 requires that the ECCS sump be visually inspected to verify there are no restrictions as a result of debris, and no evidence of structural distress or abnormal corrosion present prior to declaring the ECCS sump operable. A visual inspection of containment is performed to ensure no loose material is present which could be transported to the Containment Sump and cause restriction of the ECCS pump suction during accident conditions prior to the transition from Mode 5 to Mode 4 operations. When these inspections are performed, major outage work is complete, and any remaining loose material in containment must be logged and tracked in accordance with station procedures for control and accountability. If any debris, damage or deficiency were to be discovered during the inspection, station processes require entry into the corrective action program, with the requisite investigation and implementation of appropriate corrective action prior to the transition from Mode 5 to Mode 4.

McGuire Technical Specification 3.6.15 applies to the ice condenser drains and the refueling canal drains. An inspection of the refueling canal drain is required to ensure that each canal drain valve is locked open and each drain is not obstructed by debris prior to entering Mode 4 from Mode 5 after partial/complete fill of the canal. A visual inspection is performed every 92 days to verify that no debris is present in the upper compartment or refueling canal that could obstruct the refueling canal drains. Lastly, each ice condenser floor drain valve is visually inspected and physically tested every 18 months to ensure it is not impaired by ice, frost or debris, the valve seat shows no evidence of damage, the valve opening force is not excessive, and the drain from the ice condenser floor to the lower compartment is unrestricted.

An additional mitigative measure was taken on the McGuire refueling canal bottom drains to reduce the potential for a choke point at these locations. A perforated plate that existed on the bottom drain in the deep end of the refueling canal was removed for both Units 1 and 2. These modifications are also identified in Section 3(j), item 3(j)(2) of Enclosure 2.

3(l)(3) Summarize the evaluation of water holdup at installed curbs and/or debris interceptors.

McGuire Response:
The evaluation of post-accident ECCS sump inventory holdup in the McGuire containments includes physical diversions (e.g., curbs and filled CS piping) as well as potential debris blockage. The minimum ECCS sump pool level to ensure strainer submergence is discussed in detail in the response to RAI #41 of Enclosure 1, including the assumptions for lost inventory due to physical diversions.

3(l)(4) Describe how potential blockage of reactor cavity and refueling cavity drains has been evaluated, including likelihood of blockage and amount of expected holdup.

McGuire Response:

See responses to items 3(l)(1), 3(l)(2), and 3(l)(3) above.

3(m) Downstream effects - Components and Systems
The objective of the downstream effects, components and systems section is to evaluate the effects of debris carried downstream of the containment sump screen on the function of the ECCS and CSS in terms of potential wear of components and blockage of flow streams. Provide the information requested in GL 04-02 Requested Information Item 2(d)(v) and 2(d)(vi) regarding blockage, plugging, and wear at restrictions and close tolerance locations in the ECCS and CSS downstream of the sump.

GL 2004-02 Requested Information Item 2(d)(v)
The basis for concluding that inadequate core or containment cooling would not result due to debris blockage at flow restrictions in the ECCS and CSS flowpaths downstream of the sump screen, (e.g., a HPSI throttle valve, pump bearings and seals, fuel assembly inlet debris screen, or containment spray nozzles). The discussion should consider the adequacy of the sump screen's mesh spacing and state the basis for concluding that adverse gaps or breaches are not present on the screen surface.

GL 2004-02 Requested Information Item 2(d)(vi)
Verification that the close-tolerance subcomponents in pumps, valves and other ECCS and CSS components are not susceptible to plugging or excessive wear due to extended post-accident operation with debris-laden fluids.

General Response Note:

On December 20, 2007, the NRC issued a Safety Evaluation for WCAP-16406-P, Revision 1 "Evaluation of Downstream Sump Debris Effects in Support of GS-191", dated August 2007. Duke previously evaluated the downstream effects of sump debris on McGuire components and systems (as defined above) in accordance with WCAP-16406-P, Revision 0, dated June 2005. A comparative evaluation will be performed to address any differences extended by WCAP-16406-P, Revision 1 and the conclusions submitted to NRC by April 30, 2008 per NRC letter to Duke dated December 28, 2007. The responses and conclusions that follow, based on the original WCAP-16406-P, Revision 0 evaluation, are considered conservative and are not expected to change significantly since follow-on plant-specific testing modified the McGuire ECCS strainer design to further reduce the effect of downstream debris on components, systems, and fuel.

3(m)(1) If NRC-approved methods were used (e.g., WCAP-16406-P with accompanying NRC SE), briefly summarize the application of the methods. Indicate where the approved methods were not used or exceptions were taken, and summarize the evaluation of those areas.

McGuire Response:
An evaluation of the downstream effects (i.e., ECCS sump strainer debris bypass) of post-accident containment sump pool debris on the McGuire ECCS/CS systems was performed by Westinghouse. The evaluation considered the effect of debris ingested through the containment sump strainer on the following components that are required to operate:

- ECCS and CSS Valves
- ECCS and CS Pumps
- RHR and CSS Heat Exchangers
- ECCS and CSS orifices
- CSS spray nozzles and RHR auxiliary spray nozzles
- Piping and instrumentation tubing

The evaluations, which included the Charging, Safety Injection, Residual Heat Removal, and Containment Spray Systems, are based on the methodology developed and documented in WCAP-16406-P, Revision 0, and considers the potential effect on the aforementioned components of erosion, abrasion, and the potential blockage of flow paths.

General Methodology Application Assumptions

- The McGuire ECCS sump strainer top-hat module hole size is 3/32 inches (0.09375 inches). Thus, the debris size for hard objects is determined to be 0.09375 inches, based on the methodology outlined in Section 5.5 and Appendix J of WCAP-16406-P, Revision 0. Deformable objects of up to two times the strainer hole size by 1.1 times the strainer hole size are assumed to pass through the strainer, and are assumed to deform to pass through any downstream clearance equal to or larger than the sump strainer hole size.

- For McGuire, the ECCS mission time for ECCS/CS components is assumed to be 30 days or 720 hours, as described in Section 8 of WCAP-16406-P, Revision 0.

- The failure modes included in the pump evaluation are only those related to the pump itself (i.e., they do not include the motor, gearboxes, couplings, etc.), since the debris loading in the pumped fluid is assumed to only affect the internal components of the pump that are in contact with the pumped fluid.

Debris Size Assumptions

- Fibrous debris and RMI particulate debris are assumed to deplete per the adjusted wear model presented in the Addenda to Appendix F of WCAP-16406-P, Revision 0.
- All other particulate debris and the failed coatings debris within the break ZOI are assumed to be less than 100 microns due to the characteristic sizes presented in the NRC SER for NEI 04-07, and as such will not deplete.
- Unqualified coatings in containment are assumed to fail in a size distribution with 94% of the unqualified coatings debris greater than 400 microns which will therefore deplete; 4.5% are less than 400 microns but greater than 100 microns, and 1.5% are less than or equal to 100 microns, and these smaller particulates will not deplete. The size of the unqualified coatings debris less than 100 microns is assumed to be 50 microns on average.

Erosive and Abrasive Wear Model Assumptions

- When applying the wear caused by the debris ingested through the ECCS sump strainer, design conditions are assumed for the equipment with the exception of the pumps, where normal wear is taken into account.
- Per WCAP-16406-P, Revision 0 methodology, the abrasive and erosive wear on pumps used for service during normal plant operation is assumed to not exceed 3 mils.
- Per WCAP-16406-P, Revision 0 methodology, a debris depletion factor (λ) of 0.07 hr-1 is assumed for both abrasive and erosive wear, which accounts for the depletion of the sump pool debris.
- For the evaluation of wear on pumps, debris particles 50 microns and smaller are assumed to cause only erosive wear on the pump internals. The design running clearances in the ECCS/CS pumps typically range from 0.010 to 0.023 inches. The smallest clearance in these pumps is the radial gap, which is 0.005 inches (5 mils). Debris particles smaller than 50 microns are approximately 40% of this radial clearance and are therefore unlikely to cause abrasive wear.
- Debris particles greater than 50 microns are conservatively assumed to cause abrasive wear of the pump internals.

Methodology Exceptions

The SER for NEI 04-07 contains a requirement for licensees to assume that all coatings in containment fail as 10 micron diameter spherical particulates. Although this requirement is conservative when evaluating head loss across the ECCS sump strainer for which a "thin bed" effect is possible, it is not conservative when evaluating wear on components and valves.

The Westinghouse wear evaluation of ECCS valves and components assumes an unqualified coating particulate size distribution that varies from 110% of the ECCS sump strainer (top-hat) opening to 10 microns. This assumption is reasonable and conservative when evaluating the impact of unqualified coatings particulate on component and valve wear. There is significant public domain documentation that shows that coatings outside the conditions defined in the break ZOI will tend to fail at sizes larger than their constituent pigment size.

3(m)(2) Provide a summary and conclusions of downstream evaluations.

McGuire Response:
The following conclusions and recommendations result from the downstream evaluation of the McGuire ECCS/CS components:

ECCS/CS Valves
Having a strainer hole size of less than 0.1 inch is needed to avoid the potential for valve plugging. Of the McGuire valves that were identified as being critical to operation following a LOCA in which the ECCS recirculation mode would be required, none have the potential for plugging with the installed McGuire ECCS strainer top-hat module hole size of 0.09375 inch.

The ECCS/CS valves identified as being of potential concern for sedimentation were evaluated, and a calculation of the flow velocity through these valves determined that sedimentation is not a concern.

The ECCS/CS valves evaluated for erosive wear (i.e., throttled valves) were determined to have flow area erosion increases that remain below the acceptance criteria, and therefore erosive wear is not a concern.

ECCS/CS Pumps
The pump hydraulic wear evaluation shows that none of the McGuire ECCS/CS pump wear gaps increase to the point of causing a hydraulic performance concern.

The pump mechanical evaluation for the Safety Injection and Charging multi-stage design pumps determined that the wear ring gap increases, due to the action of erosive and abrasive debris, are less than the available wear margin of 15 mils. As a result, there is no expected pump vibration concern.

The mechanical shaft seal assembly performance evaluation determined that the carbon/graphite backup seal bushings for the ECCS/CS pumps are vulnerable if exposed to the debris-laden sump pool fluid. The backup seal bushings are only required if failure of the primary pump seal is a concern. The primary pump seal is evaluated as unlikely to fail within the ECCS mission time, and since McGuire dose analyses credit the Engineered Safety Feature atmospheric filtration system located in the Auxiliary Building, there is no requirement to consider a pump seal failure. Thus, no change to the pumps is required.

ECCS/CS Heat Exchangers
The McGuire CSS/RHR heat exchanger tube plugging evaluation demonstrated that the tube inner diameter is larger than the anticipated debris particle size. Consequently, tube plugging will not occur. The heat exchanger wear evaluation demonstrated that, because the actual wall thickness minus the thickness lost to erosion is greater than the wall thickness required to retain system pressure, tube failure due to erosion will not occur per the discussion in Section 8.3 of WCAP-16406-P, Revision 0.

ECCS/CS Nozzles and Orifices
The McGuire CSS/RHR auxiliary spray nozzle plugging evaluation demonstrated that the bore diameter is larger than the anticipated debris particle size. Consequently, plugging will not occur. For the spray nozzle wear evaluation, the increase in spray nozzle flow rate due to an increased orifice diameter remains below the acceptance limit specified in WCAP-16406-P, Revision 0, so nozzle wear is not a concern.

The ECCS/CS orifice plugging evaluation demonstrated that no orifice bore size is smaller than the largest particle that could pass through the McGuire ECCS strainer top-hat module hole size of 0.09375 inch.

The ECCS/CS orifice wear evaluation identified that the worst case (i.e., the SI pump Cold Leg injection orifice) results in flow increasing by only 2.6%, which remains below the acceptance criterion specified in WCAP-16406-P, Revision 0. Therefore, erosive wear of ECCS/CS orifices is not a concern.

ECCS/CS Instrument Lines
The McGuire ECCS/CS instrumentation tubing evaluation demonstrated that the transverse recirculation flow velocities for instrumentation locations in the ECCS and the CSS are greater than 2.94 feet per second, which is above the acceptance criterion specified in WCAP-16406-P, Revision 0. Consequently, failure of the ECCS/CS instrumentation due to debris settlement does not occur.

3(m)(3) Provide a summary of design or operational changes made as a result of downstream evaluations.

McGuire Response:
The results of the McGuire downstream debris effects evaluations on the critical ECCS/CS components demonstrate that the currently installed components are acceptable for the expected ECCS mission time. No design or operational changes are required.

3(n) Downstream Effects - Fuel and Vessel

The objective of the downstream effects, fuel and vessel section is to evaluate the effects that debris carried downstream of the containment sump screen and into the reactor vessel has on core cooling.

General Response Note:

On November 21, 2007, the NRC issued a revision to the "Content Guide for Generic Letter 2004-02 Supplemental Responses", wherein the reference to WCAP-16793 in Section 3(n) was footnoted. The footnote indicated that staff evaluation guidance (in the form of a draft SER) was expected to be available to Licensees in December 2007. As this draft guidance has not yet been submitted, Duke will address the issues in this Section based on the in-vessel debris evaluations performed, with a comparison to the original WCAP-16793-NP, Rev. 0 methodology.

3(n)(1) Show that the in-vessel effects evaluation is consistent with, or bounded by, the industry generic guidance (WCAP-16793), as modified by NRC staff comments on that document. Briefly summarize the application of the methods. Indicate where the WCAP methods were not used or exceptions were taken, and summarize the evaluation of those areas.

McGuire Response:
As identified in Section 3(m), an evaluation of the downstream effects (i.e., ECCS sump strainer debris bypass) of post-accident containment sump pool debris on the McGuire ECCS/CS systems was performed by Westinghouse. The evaluation considered the effect of debris ingested through the containment sump strainer on ECCS/CS components that are required to operate in the ECCS recirculation mode.

The evaluations, which are based on the methodology developed and documented in WCAP-16406-P, Revision 0, also consider the potential effects of downstream debris-laden sump pool fluid on the flow paths through the reactor vessel internals and the nuclear fuel.

A summary of the assumptions used in the application of the WCAP-16406-P, Revision 0 methodology for the evaluation, and the exceptions taken to this methodology, are located in Section 3(m) of Enclosure 2.

The results of the Westinghouse evaluation of the McGuire reactor vessel internals, described following, reflect the methodology described in WCAP-16406-P, Revision 0.

Reactor Vessel Internals
The smallest flow clearance found in the McGuire reactor vessel internals evaluation is 1.50 inches. The installed McGuire ECCS sump strainer top-hat modules, with 0.09375 inch holes, thus will prevent plugging by either deformable or non-deformable debris.

Additionally, low flows in the lower reactor vessel plenum, combined with the fact that the Reactor Vessel Level Indication System (RVLIS) impulse lines are dead-ended, will prevent both the entry of debris into the RVLIS connection and the collection of debris that might affect the differential pressure transmitters, per WCAP-16406-P, Revision 0 methodology. Therefore, debris ingested through the ECCS sump strainer and settling in the lower plenum of the reactor vessel will not affect RVLIS water level measurements.

A separate plant-specific debris bypass evaluation of the McGuire modified ECCS sump strainer design including the top-hat modules (with the Debris Eliminator feature), was performed to determine the size and quantity of fiber debris that might bypass the strainer and enter the nuclear fuel assemblies.

Nuclear Fuel Assemblies

Westinghouse preliminarily evaluated the quantity of fiber that might reach the nuclear fuel assemblies during containment sump recirculation. According to this evaluation, if the fiber size and quantity reaching the top or bottom of the McGuire nuclear reactor core is sufficient to develop a fiber bed with a thickness of 1/8-inch, this thin fibrous debris bed could filter out particulate debris that bypasses through the ECCS containment sump strainer and result in a debris bed with very low porosity. The low porosity through the debris bed would reduce or potentially block the flow passing through the fuel assemblies (i.e., the thin bed effect). This phenomenon is also discussed in the NRC SER for NEI 04-07. A fiber bed of 1/8-inch is utilized in the evaluation because thinner fiber beds will not provide the required structure to bridge over the passageways at the bottom and top of the nuclear fuel assemblies.

McGuire's ECCS strainer top-hat design includes a Debris Bypass Eliminator feature, designed to reduce both the fibrous debris size and quantity that could potentially enter the core downstream of the sump strainer. The effectiveness of the Debris Bypass Eliminator feature was tested, using Nukon® fiber insulation, at various flowrates and fiber/particulate debris bed mixtures consistent with the appropriate McGuire debris transport evaluation.

ECCS Sump Strainer Fiber Bypass Evaluation Method
The potential exists for small gaps/openings between the top-hat modules and plenums as well as other locations, which might allow bypass of fibrous material. Before determining the quantity of fiber that will pass through the gaps/openings

within the McGuire sump strainer plenums, the surface area of these gaps/openings is determined. Using this surface area and the test data from NRC-sponsored bypass testing (as documented in the Los Alamos Screen Penetration Test Report LA-UR-04-5416), the quantity of fiber passing through the gaps/openings is determined.

Additionally, the particulate/fibrous debris bypass through a strainer top-hat module equipped with the Debris Bypass Eliminator was independently assessed and measured in a flume test, including a resulting debris characteristic evaluation.

Using both the tested fibrous debris bypass through the gaps/openings within the sump strainer plenums, and the tested debris bypass through the strainer top-hat modules, the potential for blockage of the nuclear fuel assemblies during containment sump recirculation is evaluated.

Bypass Evaluation Assumptions

- It is conservatively assumed that all of the gaps between the cover plates and the plenums as well as the clearance between the top-hats and the plenums are equal to the 1/16-inch clearance specified on the design drawings. The clearance specified is the maximum allowable clearance. Most of the connected components will have little or no clearance between them. At many of the connections, two right-angle flow direction changes are required to allow a fiber to pass through a potential gap, thus increasing the likelihood of the fiber being trapped within the gap.
- The Nukon® and Thermal-Wrap® fiber insulation installed on the piping within the McGuire containment has a density of 2.4 lb/ft^3. It is conservatively assumed that the density of the fiber when reaching the top or bottom of the reactor core is unchanged. Typically, Nukon® and Thermal-Wrap® fibrous insulation compresses to a greater density when it builds a debris bed mixed with particulates.
- It is assumed that the wire ropes used in sealing between plenums installed inside the crane wall eliminate all bypasses through these gaps. This is reasonable because the sealing plates will be fastened tightly to the plenums with the wire ropes acting as gaskets. The plenums installed outside the crane wall are sealed with metal bands that are tightened, and then compressed by additional plates on the sides. This creates a tight seal with virtually no gap for fiber to pass through.
- Further assumptions regarding debris transport are detailed in the response to RAI #1 of Enclosure 1, and in Section 3(e) of Enclosure 2.

Bypass Evaluation Results Summary

The quantity and length of the fibers passing through the McGuire top-hat strainer modules with the Debris Bypass Eliminator feature was measured. Based on these measurements, the majority of the fiber bypass (over 98%) through the debris bypass eliminator will not build a fiber bed below or above the nuclear reactor core due to the short length of the fibers.

The quantity of fiber passing through various 1/16-inch gaps and 3/32-inch openings within the modified ECCS sump strainer design for McGuire Units 1 and 2 was conservatively determined. The total quantity of fiber that could bypass through these gaps/openings is not sufficient to develop a thin bed of debris with a thickness of 1/8-inch at the top or bottom of the nuclear reactor core. The total amount of fiber bypassed cannot provide the required structure to bridge over the passageways at the bottom and top of the nuclear fuel assemblies. Therefore, per this evaluation, sufficient open flow paths will exist for cooling of the nuclear fuel assemblies.

WCAP-16793-NP, "Evaluation of Long-Term Cooling Considering Particulate and Chemical Debris in the Recirculating Fluid," Revision 0, dated May 2007, provides analyses for assessing the effects of fibrous, particulate, and chemical debris on nuclear fuel assemblies.

The existing guidance provided to the industry is used in WCAP-16793-NP to provide the framework for the analyses that further address these concerns. Existing guidance incorporated in WCAP-16793-NP:

- WCAP-16406-P: Section 9.0 (cold leg injection, hot leg injection, fiber, particulates, etc.), including Addenda
- NEI 04-07, Volume 1: Section 7.3
- NEI 04-07, Volume 2: Section 7.3
- Draft NRC Staff Review Guidance for "Evaluation of Downstream Effects of Debris Ingress into the PWR RCS on Long Term Core Cooling Following a LOCA", dated November 22, 2005.

While the guidance in these documents provides information regarding how to assess the effects of debris on fuel, the application of these methods is stated in WCAP-16793-NP as being significantly conservative. In particular, the following conservative assumptions in the existing guidance are identified:

- All debris that penetrates the sump strainer reaches the core. Further, all fibrous debris is neutrally buoyant and is long enough to be captured at the core inlet.

- The formation of a thin bed (i.e., a bed of fiber 1/8-inch thick) at the core inlet is sufficient to preclude flow to the core based on the results presented in NUREG/CR-6224.

The WCAP then describes various evaluations and tests performed to determine the likelihood that bypass debris will adversely affect nuclear fuel assemblies, including a debris characteristics evaluation of industry-representative fibers and particulates.

Summarizing these tests and evaluations, reasonable assurance of long-term core cooling for all plants is demonstrated in WCAP-16793-NP by the following:

- The size of holes in replacement sump strainer designs limits the size of debris that is passed through the strainer during operation of the ECCS in the recirculation mode.
- Based on test observations, the characteristic dimension of this debris is typically less than the strainer hole size, even for fibrous debris. Consequently, debris buildup at critical locations in the reactor vessel and core is not expected.
- Based on data presented internationally during the resolution of the BWR strainer performance concerns, fibrous debris was observed to not strongly adhere to fuel cladding. Thus, the small size of the debris and its tendency to not adhere to fuel indicates that long-term core cooling of the fuel will not be impaired by either the collection of fibrous and particulate debris in fuel elements, or by the collection of fibrous debris on fuel cladding surfaces.
- Supporting calculations have demonstrated long-term core cooling will be maintained with about 99.4% of the core blocked. The cladding temperature response to blockage at grids and the collection of precipitation on clad surfaces was also demonstrated to be acceptable with resulting cladding temperatures less than 400°F.

The McGuire plant-specific nuclear fuel assembly debris evaluation is performed via testing and analyses that incorporate the previously available industry guidance and conservatisms. Using these techniques and acceptance criteria the McGuire modified ECCS sump strainer is shown to be capable of preventing an adverse build-up of fibrous debris on the core. Additionally, the debris characteristics evaluation of the fibers deposited downstream of the McGuire ECCS sump strainer indicates that the downstream WCAP-16793-NP debris characteristics are more limiting in size.

As such, the plant-specific fibrous debris bypass evaluations performed for McGuire are bounded by the evaluations described by WCAP-16793-NP.

Duke is aware that NRC is still evaluating the industry guidance provided by WCAP-16793-NP, and will monitor the status of this evaluation. Based on the results of the Duke-specific downstream fiber and particulate debris effects evaluations performed, significant changes to the preceding assessment of the McGuire ECCS sump strainer are not expected.

The assessment of downstream chemical effects on the nuclear fuel assemblies is also described by WCAP-16793-NP analysis methodology. This issue is addressed for McGuire in Section 3(o) of Enclosure 2.

3(o) Chemical Effects

The objective of the chemical effects section is to evaluate the effect that chemical precipitates have on head loss and core cooling.

General Response Note:
On November 21, 2007, the NRC issued a revision to the "Content Guide for Generic Letter 2004-02 Supplemental Responses", wherein the reference to both WCAP-16530-P and WCAP-16793 were footnoted. The footnotes indicated that staff evaluation guidance for these two documents (in the form of draft SERs) was expected to be available to Licensees in November and December 2007. At this time, only the draft SER for WCAP-16530-P has been issued. In it, NRC identified that WCAP-16793-NP, which specifically addresses the chemical effects concerns in Section 3(o), was still under review.

Duke will address the long-term core cooling issues identified in this Section based on the in-vessel chemical effects evaluation performed using the WCAP-16793-NP methodology issued in May 2007.

3(o)(1) Provide a summary of evaluation results that show that chemical precipitates formed in the post-LOCA containment environment, either by themselves or combined with debris, do not deposit at the sump screen to the extent that an unacceptable head loss results, or deposit downstream of the sump screen to the extent that long-term core cooling is unacceptably impeded.

<u>McGuire Response:</u>
Chemical Deposition at the ECCS Sump Strainer
Benchtop and Vertical Loop Test chemical effects testing performed by Duke is discussed in detail in the response to RAI #10 of Enclosure 1. Further chemical effects testing via the Integrated Prototype Test (IPT), designed to quantify the consequence of chemicals in the McGuire containment sump pool on the ECCS sump strainer debris bed head loss, is discussed in detail in the response to RAI #11 of Enclosure 1. The results of the IPT are being finalized and will be submitted with the supplemental response to RAI #12 of Enclosure 1. This is a commitment identified in Duke letter dated November 6, 2007, "Request for Extension of Completion Dates for McGuire Units 1 and 2 Corrective Actions Required by NRC Generic Letter (GL) 2004-02", and the associated NRC SER dated December 28, 2007. Per this commitment Duke expects to have this documentation, and to supplement the response to RAI #12, by April 30, 2008.

Chemical Deposition Downstream of the ECCS Sump Strainer

The chemical reactions of most concern for core deposition are those that release material into solution in a form where it can bypass the ECCS sump strainer, collect in the reactor vessel, and precipitate on heated fuel cladding surfaces. The chemical reactions leading to the generation of such transportable material follow:

- Corrosion or dissolution of system materials to directly produce a hydrous corrosion product that does not settle.
- Corrosion or dissolution of system materials to produce dissolved material that later forms precipitates on the fuel due to temperature change and/or pH change.
- Corrosion or dissolution of system materials followed by chemical reactions with other coolant chemicals to produce hydrous precipitates that do not settle.

Corrosion or dissolution of system materials is a first step that is common to all of the reactions. The assessment of precipitation or deposition reactions within the post-LOCA environment must be able to estimate the dissolution behavior of containment materials.

Westinghouse previously developed a method for predicting post-LOCA chemical reactions and the formation of material that could affect ECCS sump strainers in WCAP-16530-NP. This methodology has been reviewed by the NRC, and McGuire utilized it as a basis for demonstrating adequate ECCS sump strainer performance in the Integrated Prototype Test (IPT) for chemical effects described in the responses to RAI #10 and RAI #11 of Enclosure 1.

Recent NRC concerns related to post-LOCA chemical reactions have focused on the core. Specifically, the NRC identified that they expected the following chemical effects concerns be addressed:

- Assessment of chemical concentration effects due to long-term boiling
- Consideration of plate-out of deposits on the fuel rods
- Estimated effect of deposits on core heat transfer

The LOCA Deposition Analysis Model (LOCADM), described in WCAP-16793-NP, was developed to enable all plants, regardless of NSSS vendor (Westinghouse, CE or B&W) to address these concerns when documenting the viability of long-term core cooling.

WCAP-16793-NP Assumptions

The deposition method makes several assumptions that are conservative and, as a result, the predictions of deposit thickness and fuel surface temperature are considered to be bounding rather than best-estimate.

1. Once formed, deposits will not be thinned by flow attrition or by dissolution.
2. No deposition takes place apart from the fuel heat transfer surfaces. A best-estimate approach would have accounted for deposition on non-fuel surfaces such as the RHR heat exchangers and surfaces in containment, resulting in thinner core deposits.
3. The mass balance approach for determining material transport around the ECCS does not take into account any moisture carryover in the steam exiting the reactor vessel. Experimental measurements simulating the post-LOCA environment indicate that concentration of non-volatile material within the reactor vessel will be considerably reduced if moisture carryover is included in the estimation. Not including boron and coolant impurities in the moisture carryover is conservative.
4. The effect of boiling point elevation due to the concentration of solutes is not currently modeled. This simplification will result in an over-prediction of boiling in the core and thus any error introduced by the simplification will be in the conservative direction.
5. Only species that have dissolved into solution or species that have dissolved and then precipitated into suspended particles are considered. The transport of large debris particles from containment and re-deposition of debris from fuel failures have not been included. Larger debris will either settle or will be physically retained by the ECCS sump strainer, the fuel assembly inlet debris filters, or in other locations where flow is restricted. This mode of blockage is addressed in Section 3(f), Section 3(m), and Section 3(n) of Enclosure 2.
6. All impurities transported into a deposit by boiling will be deposited at a rate that is equal to the product of the steaming rate and the coolant impurity concentration.
7. The non-boiling rate of deposit build-up is proportional to heat flux and is 1/80th of that of boiling deposition at the same heat flux. This ratio is based on empirical data for mixed calcium salts under boiling and non-boiling conditions.
8. The deposition of impurities on the fuel clad surface is assumed to be distributed according to the core power distribution.

WCAP-16793-NP Evaluation Results
Evaluation of chemical effects in the core region to form precipitation on the cladding surface was performed. Considering the variation in plant-specific chemistries, this evaluation was performed by extending the method of WCAP-16530-NP to estimate the potential for plate-out on the surface of fuel cladding. This method is available for all Westinghouse, CE and B&W plants to perform plant-specific evaluations in which their plant-specific chemistry is accounted for.

Sample calculations were performed using particularly challenging plant chemistries, and fuel clad temperatures were predicted to remain below 400°F over a 30-day period following the postulated event. Due to the interaction of several of the parameters, WCAP-16793-NP suggests that plants perform a plant-specific evaluation by comparison to these sample calculations to confirm that chemical plate-out on the fuel does not result in the prediction of fuel cladding temperatures approaching the 800°F acceptance basis value.

Comparison to the sample calculations presented in WCAP-16793-NP shows that the predicted McGuire post-LOCA conditions and chemistry parameters are bounded by the WCAP analyses, and therefore the long-term cooling capability of the McGuire nuclear core is not impeded by downstream chemical effects.

WCAP-16793-NP and Boric Acid Precipitation
The effect of sump debris and sump chemical compounds on boric acid precipitation has been reviewed with respect to displaced liquid volume, the potential impact on assumed mixing volumes, alternate flow paths, and chemical effects as it pertains to potential precipitates in the core. It is concluded that sump debris and related chemical effects do not create a boric acid precipitation concern and that the introduction of debris to the RCS does not significantly affect the current licensing basis boric acid precipitation calculations. Therefore, the current accepted licensing calculations that demonstrate appropriate boric acid dilution to preclude boric acid precipitation remain valid.

3(o)(2) Content guidance for chemical effects is provided in Enclosure 3 to a letter from the NRC to NEI dated September 27, 2007 (ADAMS Accession No. ML0726007425).

McGuire Response:
Enclosure 3 to the letter from NRC to NEI dated September 27, 2007 ("Evaluation Guidance for the Review of GSI-191 Plant-Specific Chemical Effect Evaluations"--ADAMS Accession No. ML072600372) is draft guidance for the staff (and licensees) to ensure the chemical effects portions of Generic Letter 2004-02 plant-specific evaluations appropriately address the chemical effects that can occur following a postulated loss of coolant accident (LOCA). This guidance invokes industry testing methodology and observations of industry

testing to facilitate the process of assessing potential concerns, formulating plans of testing, conducting tests, and evaluating test results.

As noted previously, Duke's strategy for addressing chemical effects on the McGuire modified ECCS sump strainer are addressed in the responses to RAI #10 and RAI #11 of Enclosure 1, which describe the preliminary and plant-specific chemical effects testing (Integrated Prototype Test) performed and the industry-related bases for the development of the tests.

3(p) Licensing Basis

The objective of the licensing basis section is to provide information regarding any changes to the plant licensing basis due to the sump evaluation or plant modifications. Provide the information requested in GL 04-02 Requested Information Item 2.(e) regarding changes to the plant licensing basis. The effective date for changes to the licensing basis should be specified. This date should correspond to that specified in the 10 CFR 50.59 evaluation for the change to the licensing basis.

<u>GL 2004-02 Requested Information Item 2(e)</u>
A general description of and planned schedule for any changes to the plant licensing bases resulting from any analysis or plant modifications made to ensure compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of this generic letter. Any licensing actions or exemption requests needed to support changes to the plant licensing basis should be included.

<u>McGuire Response:</u>
The discussion of the McGuire licensing basis requested in Section 3(p) is provided in Section 1 of Enclosure 2, Overall Compliance.