Florida Power & Light Company, 6501 S. Ocean Drive, Jensen Beach, FL 34957

FPL

July 30, 2009

L-2009-180
10 CFR 50.54(f)

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
11555 Rockville Pike
Rockville, Maryland 20852

Florida Power & Light Company
St. Lucie Unit 1
Docket No. 50-335

Subject: Additional Responses to the NRC's Request for Additional Information

References:

(1) Letter from S. P. Lingam (U. S. Nuclear Regulatory Commission) to M. Nazar (FPL), "St. Lucie Unit 1 – Generic Letter 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors," Request for Additional Information" January 22, 2009 (TAC NO. MC4710) (ML083580023)

(2) Letter L-2008-030 from G. L. Johnston (FPL) to U. S. Nuclear Regulatory Commission, "Supplemental Response to NRC Generic Letter 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," dated February 27, 2008 (ML080650560)

(3) Letter L-2008-137 from G. L. Johnston (FPL) to U. S. Nuclear Regulatory Commission, "Supplemental Response to NRC Generic Letter 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," dated June 30, 2008 (ML081840513)

(4) Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," dated September 13, 2004 (ML042360586)

(5) Letter L-2009-084 from G. L. Johnston (FPL) to U. S. Nuclear Regulatory Commission, "Response to NRC's Request for Additional Information," dated April 22, 2009 (ML091210225)

On January 22, 2009 the U. S. Nuclear Regulatory Commission (NRC) requested additional information (RAIs) (Reference 1) regarding the Florida Power and Light Company's (FPL) Supplemental Information provided previously (References 2 and 3) on the subject of the NRC's Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors" (Reference 4).

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On April 22, 2009, FPL submitted responses (Reference 5) for the NRC's RAIs. However, the responses for several of the RAIs (RAI-7 and RAI-10 c through g, k, and l) stated that responding at that time would not be pertinent or informative because of new activities being performed by FPL; and that responses for these RAIs would be provided by July 30, 2009. This submittal provides FPL's additional responses.

Attachment 1 provides the responses for RAI-7 and RAI-10 c through g, k, and l for St. Lucie Unit 1. Additionally, three of the previously submitted responses (for RAIs 6, 10 h, and 10 i) have been revised based on the results of analyses and testing that have recently been completed.

The new activities performed by FPL included debris transport analysis, and additional debris and chemical effects flume testing. The flume testing supplants testing that was performed earlier by the strainer vendor. FPL is revising the June 30, 2008 supplemental response (letter L-2008-137) (ML081840513) including the information under the Debris Transport topic and the Chemical Effects topic which are being completely revised and will be submitted to the NRC by July 30, 2009.

This information is being provided in accordance with 10 CFR 50.54(f).

Please contact Mr. Ken Frehafer at (772) 467-7748 if you have any questions regarding this response.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on July 30, 2009.

Sincerely yours,

Gordon L. Johnston
Site Vice President
St. Lucie Plant

Attachment: (1)

Attachment 1

St. Lucie Unit 1

Additional Responses to the NRC's RAIs Dated January 22, 2009 for FPL's Generic Letter GL 2004-02 Supplemental Responses, Dated 02/27/2008 and 06/30/2008

Introduction

This submittal provides the Florida Power and Light Company's (FPL) additional responses to the U. S. Nuclear Regulatory Commission's (NRC) request for additional information (RAIs) dated January 22, 2009 regarding FPL's Supplemental Information provided previously on February 28, 2008 and June 30, 2008, on the subject of the NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors."

On April 22, 2009, FPL submitted responses to the NRC's RAIs. However, the responses for several of the RAIs (RAI-7 and RAI-10 c through g, k, and l) stated that responding at that time would not be pertinent or informative because of new activities being performed by FPL; and that responses for these RAIs would be provided by July 30, 2009. The new activities included performing a debris transport analysis and debris and chemical effects flume testing. The new activities have been completed. The responses for the remainder of the RAIs are provided below. Additionally, three of the previously submitted responses (for RAIs 6, 10 h, and 10 i) have been revised based on the results of analyses and testing that have recently been completed. Changes to these three responses are shown in the text with revision bars.

FPL is revising the June 30, 2008 supplemental response (letter L-2008-137). The information under the Debris Transport topic and the Chemical Effects topic is being completely revised and will be submitted to the NRC by July 30, 2009.

List of Acronyms

CFD	computational fluid dynamics
CS	containment spray
CSAS	containment spray actuation signal
CSS	containment spray system
ECCS	emergency core cooling system
EOP	emergency operating procedure
FPL	Florida Power and Light Company
GL	Generic Letter
GSI	generic safety issue
HPSI	high pressure safety injection
LBLOCA	large break loss of coolant accident
LOCA	loss of coolant accident
LPSI	low pressure safety injection
NEI	Nuclear Energy Institute
NPSH	net positive suction head
NRC	U. S. Nuclear Regulatory Commission
PSL-1	St. Lucie Unit 1
RAI	request for additional information
RAS	recirculation actuation signal
RCS	reactor coolant system
RWT	refueling water tank
SBLOCA	small break loss of coolant accident
SE	safety evaluation
SIT	safety injection tank
TS	Technical Specifications
ZOI	zone of influence

RAI-6: Describe in more detail the methodology used to estimate the total area of tapes, stickers, and miscellaneous debris. Include any assumptions that would reduce the quantity of material transported to the sump screen.

RAI-6 RESPONSE:

Miscellaneous Debris Methodology

As described in Topic 3.d, Latent Debris, of the FPL supplementary submittal, the foreign debris information for St. Lucie Unit 1 is based on walkdowns performed on St. Lucie Unit 2.

St. Lucie Unit 1 and St. Lucie Unit 2 are of similar design. The internal containment horizontal and vertical surfaces are similar. The procedures for containment close out and the organizations who perform these procedures are the same. For foreign debris, the procedures for labeling and lights are similar between St. Lucie Unit 1 and St. Lucie Unit 2. Therefore, the foreign debris for St. Lucie Unit 1 used the St. Lucie Unit 2 total plus 25% to account for any discrepancies.

The containment walkdowns were performed to identify and measure plant labels, stickers, tape, tags, and other debris in accordance with the guidelines in the walkdown plan. Equipment tags located in containment will become debris, unless they are located outside the Zone of Influence (ZOI) of the postulated pipe break and are qualified for the post loss of coolant accident (LOCA) environment. Therefore, post LOCA qualified equipment tags located outside the ZOI (attached by wire, threaded fastener, rivets or qualified tie wraps) are not counted as debris.

Accessible containment areas were examined during the walkdown. Stickers, labels and other debris were quantified, measured and recorded on the Foreign Material Record Sheets. All miscellaneous or non-recurring items were captured individually. Several types of labels and stickers were found consistently on certain plant structures and equipment throughout containment and were measured. The total number of light bulbs in containment lighting was established by drawings, specifications or equipment lists as applicable.

It was observed that many items, such as junction boxes, conduits, and cable trays were marked with paint rather than a label or sticker and therefore will not create any foreign debris. Other items such as post LOCA qualified conduit labels (metal tags attached by metal wire or rivets) will not become debris following a GSI-191 pipe break unless they are located in the ZOI. The specific items that could potentially become foreign debris are discussed below.

Light Bulbs

Lighting is located throughout containment and primarily consists of a metal fixture that is a hemisphere opening toward the floor containing a light bulb enclosed by a protective heavy glass cylinder. The light bulbs are standard industrial size and were modeled as a 4" diameter sphere. The protective glass covering was conservatively modeled as an open-end cylinder that is 8" long with a 4.5 " diameter hemisphere. The metal fixtures will not be affected by containment spray or elevated containment pressure during a GSI-191 event and will not become transportable debris due to a pipe break. Light bulbs can potentially break and become debris during post LOCA conditions due to the increased pressure inside containment. However, the protective glass cylinder enclosures will not break due to elevated containment pressure because they are not air tight (elevated containment pressure will equalize across the inner and outer glass surfaces). As a result, the protective light bulb glass enclosures will capture and contain any broken or shattered light bulb glass. However, containment lighting located in the ZOI will break and potentially contribute debris loading to the containment sump. Conservative evaluation of plant lighting in the ZOI at the 18' elevation of containment (including platforms in this location) determined that 34 plant lights could become debris during a GSI-191 event.

Adhesive

Adhesive residue was found at numerous locations throughout the plant. Based on walkdown observations and discussion with plant personnel, a significant number of various signs have been removed inside containment with adhesive residue remaining behind in many areas. The adhesive is usually very thin and 1/32" was used as the adhesive thickness to determine the total volume of adhesive (except for ten (10) 10" x 0.75" patches of adhesive found on containment walls at elevation 62' - 0"). It was conservatively assumed that all adhesive will become debris during LOCA conditions.

Equipment Tags

Equipment inside containment is labeled with a 4" x 2.25" hard plastic tag. The tag is attached to equipment by metal wire. Equipment tags attached by metal wire will not become debris outside the ZOI. Equipment tags that are within the ZOI will become debris during a LOCA. As a result, equipment tags were counted in the ZOI of one loop (Loop B) to determine the total number of equipment tags that would become debris during a LOCA. A total of approximately thirty five (35) tags were counted in the ZOI. For conservatism, fifty (50) was used as the total number of equipment tags that will become debris inside the ZOI during a LOCA.

Miscellaneous

Tape and stickers are located throughout containment and were individually counted during the walkdown.

Results

Based on the walkdowns, containment foreign material debris totals were tabulated. These materials are assumed to become available for transport to the containment sump during a postulated LOCA. A 10% margin was added to the label, sticker, tape, placards, etc. total to account for areas of containment that were inaccessible during the walkdown due to high dose rate or ongoing work activities. An additional 25% of miscellaneous debris was added to the Unit 2 results in order to account for differences between Unit 2 and Unit 1.

Material Transport Assumptions

No assumptions were made that would reduce the quantity of foreign debris material transported to the sump screen.

RAI-7: The staff considers the technical basis supporting the transport fraction of 0.3417 calculated for Nukon and Thermal Wrap fibrous debris to lack an adequate supporting technical basis. The method used by the licensee appears to be a simplified hand calculation that is a variation on the nodal network approach that was considered reasonable by the safety evaluation (SE) on NEI 04-07 only if supported by experimental data. The transport methodology used for St. Lucie Unit 1 is not consistent with the approved guidance on debris transport in the SE on NEI 04-07, and the technical basis provided in the supplemental response is not adequate to justify the alternate approach (hand calculation) chosen. Address the following staff concerns:

a. It is unclear how blowdown, washdown, and pool-fill transport were analyzed.

b. The supplemental response identifies only three distinct velocities in the entire containment pool: 0.113 ft/s inside the bioshield, 0.14 ft/s for 26.4% of the area outside the bioshield and 0.07 ft/s for the other 73.6% of the area outside the bioshield. The resolution (number of nodes in the licensee's calculation) does not appear sufficiently fine to provide a prototypical or conservative representation of actual flows in the containment pool.

c. Based on the information provided, it is unclear how 20.6% of the sump pool was calculated to be a "turbulent zone" for large pieces and 30.6% was calculated to be a "turbulent zone" for small pieces. Furthermore, it is not clear that turbulence is the controlling parameter for the tumbling of small and large pieces of debris across the containment floor (e.g., versus velocity), or how a hand calculation can provide a reasonable estimate of the turbulence in the containment pool.

d. It is unclear how the kinetic energy of the break flow and containment sprays was modeled. This flow splashing down into the containment pool can have a significant impact on the velocity and turbulence distributions in the containment pool. For St. Lucie Unit 1 the licensee assumed uniform containment spray drainage. However, the drainage from containment sprays frequently is not at the containment pool elevation due to non-uniformities in the structures at higher elevations that can result in concentrated drainage (e.g., refueling canal drains, hatch openings, gaps in curbs, etc.).

e. The calculation appears to assume that all flow enters the physically nearest strainer module. This assumption is not likely to be valid for modules nearest the bioshield exits carrying the majority of the break flow (note that many licensees have seen significant tangential velocity components or swirling flow patterns near such modules). Neglecting tangential or swirling flow patterns leads to an under-prediction of the velocities throughout the containment pool and local to the strainer modules. Furthermore, without internal strainer flow control, it is not clear that modules nearest the sump suction pipes would not preferentially draw flow, particularly in light of the potential for the clean strainer head losses to result in non-uniform flow.

f. No experimental data was provided to support the simplified analytical hand calculations.

RAI-7 RESPONSE: This RAI is based on information provided to the NRC on June 30, 2008, by the Florida Power and Light Company (FPL) in the supplemental response to NRC Generic Letter 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation during Design

Basis Accidents at Pressurized-Water Reactors.

The information provided in the June 30, 2008 supplemental response was based on transport estimates supplied by the strainer manufacturer in their Hydraulic Sizing Report. In that report, estimates of the amount of fiber transported to the sump strainers were made. These estimates were based on the highest design basis flow rates with high pressure safety injection (HPSI) and containment spray (CS) pumps operating including one low pressure safety injection (LPSI) pump augmenting hot/cold leg recirculation. This resulted in a design basis flow rate of 8,530 gpm. This flow rate was conservatively assumed for the entire duration of the event.

Subsequently, on October 29, 2008, FPL notified the NRC that additional analysis and testing would be performed in order to address additional issues that were raised by the NRC staff. FPL performed a debris transport analysis that accounted for the limiting single failure flow rate in accordance with the NRC staff's guidance.

A full debris transport analysis was completed using Computational Fluid Dynamics (CFD) for the design basis flow case to augment previous analyses. This transport analysis includes the evaluation of a flow case where a LPSI pump is assumed to fail to trip on a recirculation actuation signal (RAS) with a resultant flow rate of 11,630 gpm. The flow rate for this LPSI pump failure to trip analysis is higher than the previously mentioned hot/cold leg recirculation case.

The additional analysis includes consideration of blowdown, washdown, and pool-fill transport prior to the initiation of recirculation. The analysis considers the complete range of applicable pool velocities as a function of distance from the strainer modules. The analysis also considers CS flow distributed evenly over the pool. This is conservative for debris transport because most of the spray would actually be diverted away from the break area to outside the biological wall due to the presence of the operating deck floor above the break. Additionally, the refueling canal drains are on the opposite side of containment from the limiting break and the debris, and would not be expected to wash as much debris to the sump strainers.

In the event the low pressure safety injection (LPSI) pump fails to trip, the emergency operating procedures (EOPs) direct the operators to manually secure the pump. However, for conservatism, the entire transport analysis was evaluated based exclusively on the higher flow rates associated with the LPSI pump failure to trip case. The transport analysis also evaluated all strainers for a relatively evenly distributed flow case (case 1), and for a non-uniform flow case associated with the equivalent of clean strainer operation (case 4). The transport fraction for fiber was determined to be approximately the same (about 43%) for both cases. Note that this transport fraction is comparable to the transport fraction previously reported (34%). The larger transport fraction is reflected by the increase in flow rate from 8,530 to 11,630 gpm. Subsequent strainer head loss testing has utilized the larger transport fraction.

The transport analysis due to blowdown, washdown, and pool fill were calculated in the debris transport calculation. The methodology used in the analysis was developed using the guidance contained in NEI 04-07 volumes 1 and 2.

The following discussion is a summary of the transportation analysis methodology and results of the blowdown, washdown, and pool fill, as documented in the debris transport calculation . The St. Lucie Unit 1 debris transportation calculation developed the transportation logic for large and small debris associated with the St. Lucie Unit 1 break designated as "S1" worst case break location.

Small Debris Distribution

This discussion is a summary of the methodology applied to small debris. The lower containment was divided into seven (7) zones, as shown in Figure 7-1 below for illustration. Based on NEI 04-07 Volume 2, 25% of the small debris was transported vertically into upper containment and 75% remained in the lower containment. For conservatism it was assumed that all of the small debris that remained on the lower elevation was retained in zones 1 and 2 and subject to break flows during pool fill.

After the initial blast the small debris was redistributed throughout containment due to pool fill effects and containment spray washdown effects. All small debris blown into the upper containment elevations were conservatively washed down to the lower elevation in zones 5 and 6 due to their close proximity to the containment sump. A small portion, 13.37% of the washdown debris was trapped in the inactive containment pool and not subject to transport to the strainer. Of the debris that remained in lower containment 13.37% was sequestered by the inactive pool volume, and the remaining 86.63% was available for further transport. Based on the approximate volume of water inside the secondary bioshield to the volume of water outside the secondary bioshield wall 92% of the non-sequestered small debris remained in zones 1 and 2. The remaining 8% transported through the secondary drain portals into zones 5, 6, and 7. The distribution logic for small debris is presented below in Figure 7-2.

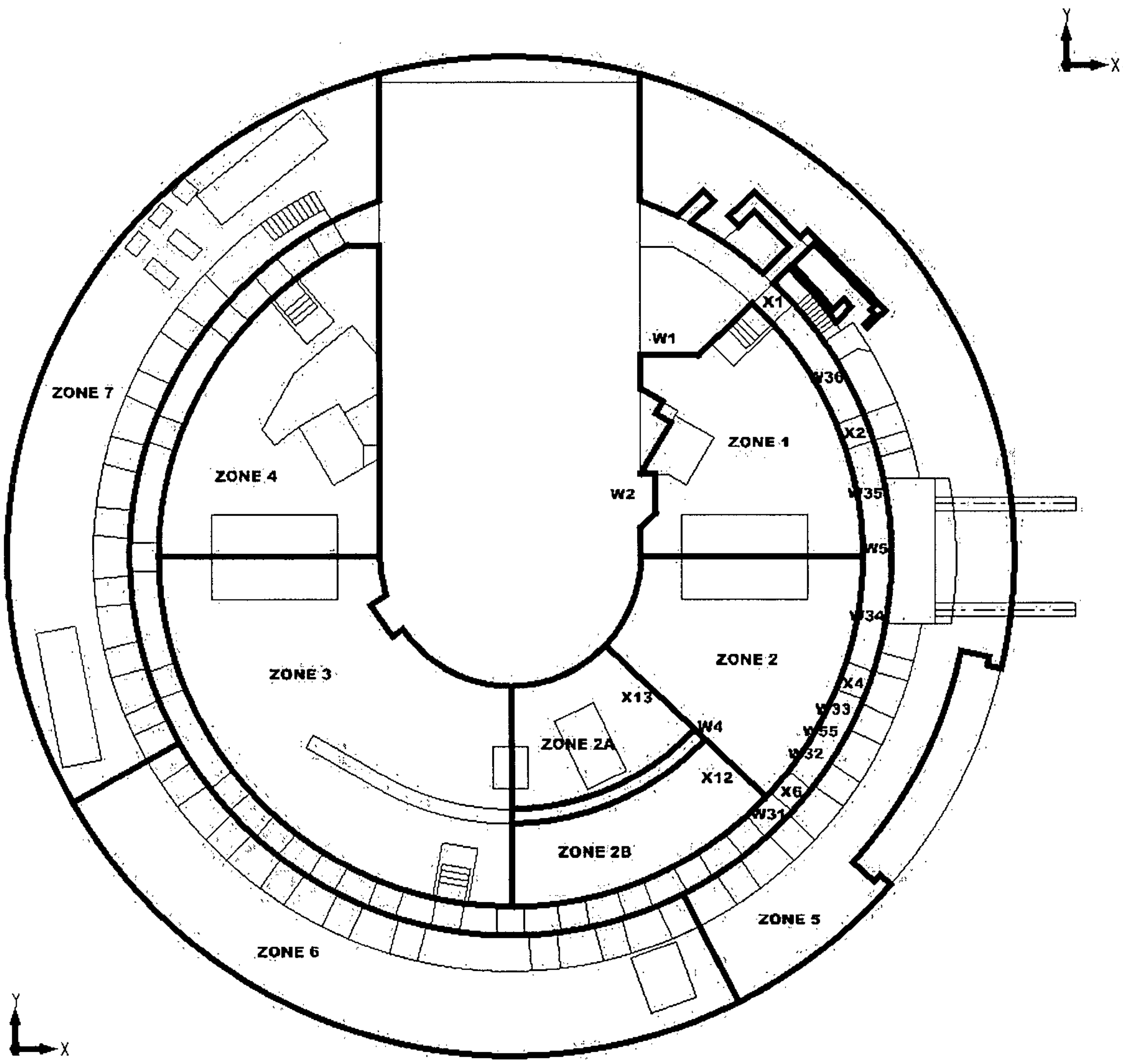

Figure 7-1: Containment Zone Locations

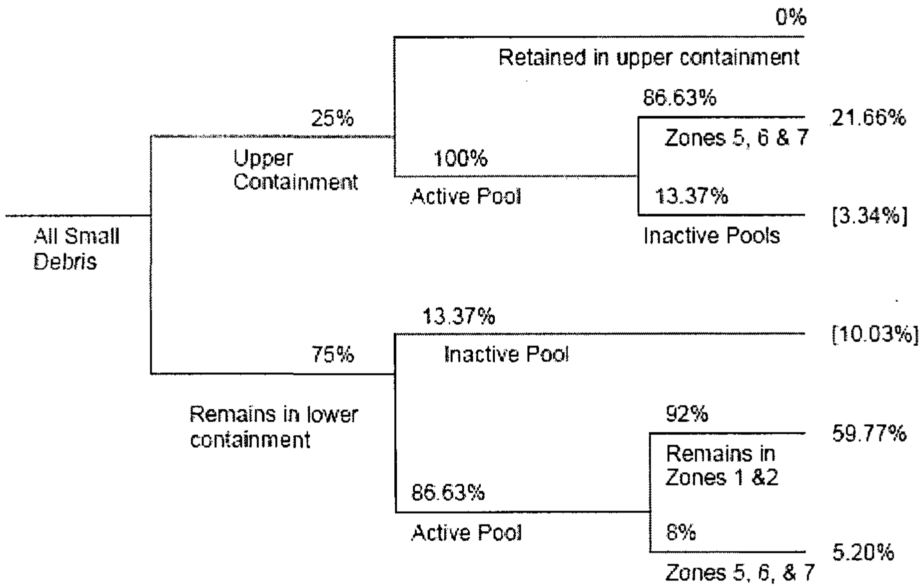

Figure 7-2: Distribution Logic for Small-Sized Debris that Originates in Proximity Zones 1 and 2 through Blowdown and Pool Fill Transport

Large Debris Distribution

Large debris was assumed to be largely influenced by gravity and remain in containment zones 1 and 2 post blowdown. The large debris was then distributed to various walls and wall openings based on the ratios of the total wall and opening lengths to individual wall and wall openings lengths. For conservatism large debris was not subjected to being trapped in the inactive containment pool. The ratios are further enhanced by accounting for the distance between the break and the object (wall or opening).

Initially large debris is assumed to be evenly spread over areas of zones 1 and 2. "S" values are the measured width of the opening. "L" values are the distance from the break to the center of the opening. Using the S/L ratio of the openings compared to the total S/L ratios, 13.04% of the large debris transports to the portal openings. The pool fill hydraulics will push the remaining large debris against the walls in zones 1 and 2, however 25% of the debris is assumed to shear off the wall (for conservatism) due to flow and transport along the walls to the drain portals. The debris that is transported to open portals (portals without strainers X1 and X2) will pass through and be deposited in the trench just beyond the portal opening. Debris that transports to portals with strainers (strainers installed in the drain portals X4 and X6) collect at the portal opening and will be available for further transport based on CFD analysis. Figure 7-1 shows the locations of these drain portals.

Additionally 10% of the large debris that remains trapped along the containment walls will be eroded to fines and available for further transport via the CFD analysis.

The distribution logic for large debris is presented below in Figure 7-3.

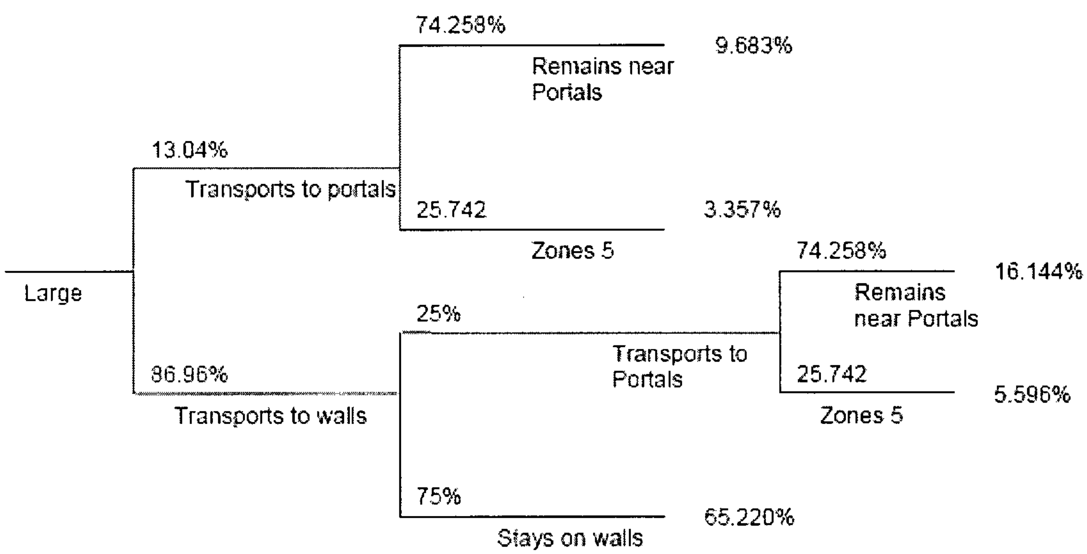

Figure 7-3: Distribution Logic for Large-Sized Debris

Inactive Pool

13.37% of the St. Lucie Unit 1 containment sump pool was calculated to be inactive. The inactive pool percentage was determined by calculating the volume of the inactive pools (11,360.8 ft^3) and dividing by the total containment pool volume (84,928.9 ft^3). For conservatism only small debris was subjected to inactive containment pool sequestering.

CFD Modeling

A CFD model was developed to determine the flow velocities throughout containment. The CFD model flow velocities are compared to the settling and incipient tumbling velocities for small debris to determine the portions of each zone that contribute to debris reaching the strainer. The settling and incipient tumbling velocities used in the analysis were obtained from NUREG/CR-6772. The conclusion of the CFD analysis determined the total quantity of individual debris types calculated to reach the vicinity of the strainer due to debris transport.

The flume geometry is used to reproduce the weighted average approach flow velocities and velocity gradients through which debris travels near the strainer modules. The volume of material introduced in the flume is based on the volume of material predicted to move to the vicinity of the strainer array in the debris transport calculation.

Additional Considerations

This section will discuss additional conservatisms with respect to pool fill and washdown. Figure 7-4 below shows the location of the ECCS strainers and the design basis break location. Note that the strainers are located on the 18 ft elevation.

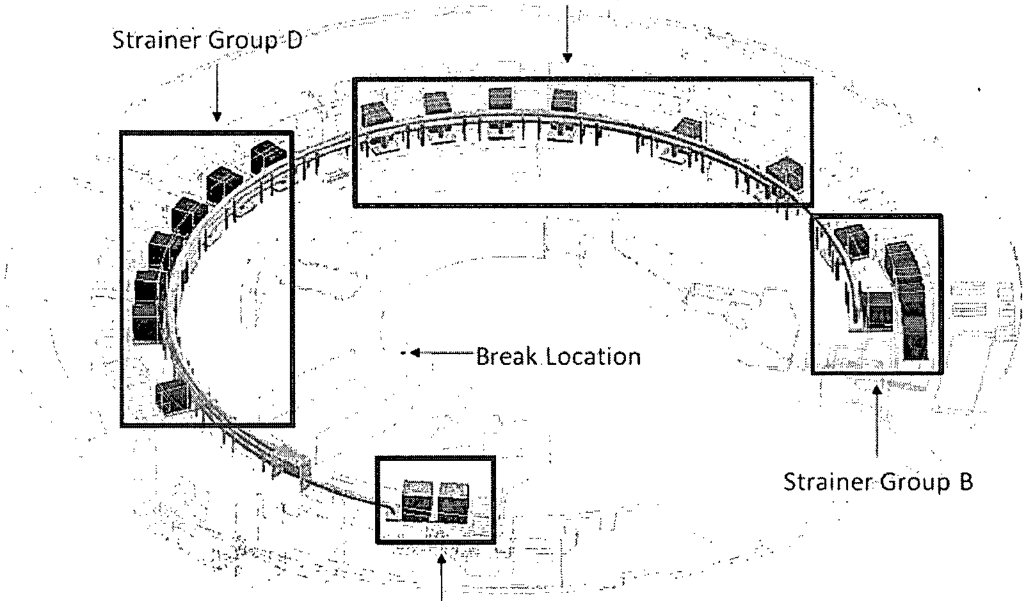

Figure 7-4: Isometric of St. Lucie Unit 1 ECCS Strainer System

As water inventory is initially released from the LOCA break location, it will create sheeting flow on the floor and tend to sluice debris away from the break location. As the sheeting flow spreads across the containment floor (18 foot elevation) it will begin to encounter the drain portals. Flow will pass through the drain portals and spill into the pipe chase (elevation 12 ft and elevation 16 ft) and the ECCS sump (elevation 7.58 ft). Due to the Reactor Coolant Drain Tank location in the ECCS sump, the sump volume is relatively small compared to the total volume of water released during a LOCA. Therefore the total volume of water directed to the ECCS sump during this time period is small relative to the total volume of water released during the course of the LOCA.

As the pool fill continues, the pool level will increase until it exceeds the curbs at elevation 18.5 ft. When the level exceeds elevation 18.5 ft the pool level will cease to increase as the electrical access tunnel, reactor cavity access tunnels, and the reactor cavity sump are flooded and equalized with the containment pool. Since the containment pool fill flows are turbulent at a depth of 6 inches on the 18 ft elevation floor, a significant percentage of the debris is expected to be suspended and as such the flow streams are expected to direct debris into the inactive pool. Although only 13.37 % was credited, the higher velocities at the lower sump level would be expected to transport a higher fraction to the inactive pool. Once the inactive pool volume has flooded and equalized with the containment pool, the overall containment pool level will continue to increase as water inventory is released from the LOCA break site. The velocities in the sump pool will decrease as the level increases, and as such any debris not transported to the inactive pool is expected to begin to settle. Note that the expected response described above is not credited in the debris transport calculation and represents additional conservatism in the analysis.

In addition to the phenomenon described above, the scaling factor for determining the test strainer size, test flow rates, and test debris quantities included significant conservatisms which are related to the pool fill. Figure 7-4 shows that the break location is close to the E group of strainers. Due to the proximity to the break, it could be postulated that more debris would be washed into this strainer. For the purposed of scaling, both of the strainer modules were considered 100% blocked. Also, two additional strainer modules were considered 100% blocked. Because of conservative reductions the strainer area used for scaling was 6,527 ft^2. compared to the total strainer area of 8,187 ft^2. This represents yet another conservatism in the analysis.

Turbulent kinetic energy was specified at the water surface where the water from the sprays is assumed to enter the pool. Spray flow is introduced into the containment building from spray headers located in the upper containment. The water from these sprays travels to the pool through all available openings at each elevation. In the St. Lucie Unit 1 containment, the path from the upper containment to the pool is generally inside and outside the secondary bio shield wall. The operating floor of containment is generally concrete to a radius of 56 ft. From a radius of 56 ft to 68 ft – 2 inches the floor is generally grating. However, there are numerous openings in the concrete around components such as the steam generators. Although it is acknowledged that the flow distribution will not be even, the tortuous path from the upper elevations to the containment sump will break up streams of water flowing downward. The spray flow in general was assumed to fall as discrete drops, representing the disassociation of the water as it falls from the upper levels and its impact on equipment and structures. Droplets impacting the water surface with terminal velocities approaching that of large raindrops essentially do not penetrate the water surface and the associated small kinetic energy associated with the impact is limited to the regions near the free surface.

The transport methodology used for St. Lucie Unit 1 is consistent with the approved guidance on debris transport as described in the NRC staff's SE on NEI 04-07. FPL's June 2008 supplemental response under the Debris Transport topic is being revised and will be submitted to the NRC by July 30, 2009.

RAI-10: The extrapolation of test results to parameters other than tested conditions is discussed in the supplemental response. It states that the strainer sector test head loss was scaled to the full sized strainer system based on velocity, kinematic viscosity, and bed thickness differences. State all extrapolations or scaling that was performed for the head loss evaluation. Provide the methodology for all scaling including the inputs and assumptions used.

c. It was implied that the debris was added to the sector test prior to starting the recirculation pump. Either verify that the pump was started before debris addition or provide details on the test sequence and justification that adding debris prior to starting the recirculation pump would result in prototypical or conservative head loss values.

d. Provide documentation of the testing methodology including:

1. debris introduction sequences (debris type and size distribution) including time between additions
2. description of test facility
3. general procedure for conducting the tests
4. debris introduction locations within the test flume
5. comparison of actual fibrous size distribution added during the test versus fibrous sizes predicted in the transport evaluation
6. particulate debris size distributions
7. amounts of each debris type added to each test
8. test strainer area
9. test flow rates
10. description of debris introduction procedures including debris mixes and concentrations showing that fibrous debris agglomeration did not occur
11. thin bed test debris introduction sequences
12. incremental amounts of fibrous debris added for thin bed tests

e. Provide documentation of the amount of debris that settled in the agitated and nonagitated areas of the test tank.

f. Provide information that shows how test results were extrapolated to emergency core cooling system mission times or provide a discussion of how the test results were determined to bound the head loss during the entire required mission time. If a mission time based net positive suction head (NPSH) margin evaluation was used, provide NPSH margin values for the entire mission time.

g. Provide the test termination criteria and sufficient data to show that the test was run in accordance with the termination criteria.

k. The supplemental response stated that the strainer sector test cases were observed and photographed to ensure that absence of bore holes. However, bore holes cannot be detected visually with assurance. Additionally, some post-test photos indicate that there was clean strainer area following the test. In order to assure that viscosity correction is applicable to test results, flow sweeps should be conducted for conditions on which extrapolations are based (e.g., there should not be open screen area, nor should there be pre-existing bore holes). Provide information that provides additional justification that bore holes did not occur during testing. In addition, provide an evaluation of whether the clean strainer areas would affect the results of the extrapolation to higher temperatures.

l. The supplemental response stated that debris was prevented from settling using stirring. No information was provided to show that the stirring did not drive non-prototypical debris onto the bed or prevent debris from collecting naturally on the strainer. Provide information that verifies that the stirring did not result in non-prototypical bed formation.

RAI-10 c through g, k and l RESPONSE: This RAI is based on information provided to the NRC on June 30, 2008, by the Florida Power and Light Company (FPL) in the supplemental response to NRC Generic Letter 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors.

The information provided by FPL in the June 30, 2008, supplemental response was based on test results supplied by the strainer manufacturer in their Hydraulic Sizing Report. In that report, estimates of the amount of strainer test head losses were reported. These estimates were based on tests performed at the highest design basis flow rates, scaled for strainer area, with high pressure safety injection (HPSI) and containment spray (CS) pumps operating including one low pressure safety injection (LPSI) pump augmenting hot/cold leg recirculation. This resulted in a design basis flow rate of 8,530 gpm. This flow rate was conservatively assumed for the entire duration of the event for the design flow case.

Subsequently, on October 29, 2008, FPL notified the NRC that additional analysis and testing would be performed in order to address additional issues that were raised by the NRC staff. FPL performed chemical effects testing that accounted for the limiting single failure flow rate in accordance with the NRC staff's guidance.

The additional chemical effects flume testing supplants that performed earlier by the strainer vendor and involves a completely different methodology and test article. Detailed responses to RAIs about test results that are no longer being used would not be relevant or informative. Rather, FPL's June 2008 supplemental responses under the Debris Transport topic and the Chemical Effects topic will be completely revised and submitted to the NRC by July 30, 2009 with this information. The following is a brief description of the additional actions performed.

FPL's additional actions included completion of a full debris transport analysis using Computational Fluid Dynamics (CFD) for the design basis flow case to augment previous analysis. This analysis includes the evaluation of a flow case where a LPSI pump is assumed to fail to trip on a recirculation actuation signal (RAS) with a resultant flow of 11,630 gpm. The flow rate for the new analysis is higher than the previously mentioned hot/cold leg recirculation case. Large flume head loss testing was then conducted by AREVA at Alden Labs which incorporated the revised transport data and flow rates. The flume testing utilized an entire strainer module rather than strainer disc sectors. Debris (except for some latent debris) was added to the test flume after the start of flow. No agitation of the flow stream was used. Flow sweeps were conducted to confirm the absence of boreholes. Full chemical debris was conservatively considered from near the beginning of testing rather than a chemical effects bump up factor based on separate testing as had been done previously. Full debris/precipitate maximum head losses were measured at 30 hours and started to decrease, and were conservatively applied for the entire mission time. Further details are provided in the July 30, 2009 supplemental response.

RAI-10: The extrapolation of test results to parameters other than tested conditions is discussed in the supplemental response. It states that the strainer sector test head loss was scaled to the full sized strainer system based on velocity, kinematic viscosity, and bed thickness differences. State all extrapolations or scaling that was performed for the head loss evaluation. Provide the methodology for all scaling including the inputs and assumptions used.

h. The flashing evaluation did not provide the margin to flashing through the strainer. The submittal stated that a small amount of air pressure is credited, but the amount of overpressure required was not provided, nor was the available margin. The total head loss, including chemical effects, was listed as 11.42 ft at 210°F with a submergence of less than 1 ft. Provide information that shows that flashing will not occur within the strainer. Include the inputs and assumptions used to make this determination. Provide the margin to flashing at the limiting point during recirculation.

RAI-10h RESPONSE: FPL has performed a flashing analysis which determines the margin to flashing across the sump screens for two different flow cases for St. Lucie Unit 1. The first case is for the LPSI pump failure to trip on RAS case with a clean strainer. St. Lucie EOPs require operators to manually stop the LPSI pump upon failure to automatically stop on RAS. FPL has evaluated this response and concluded that the mandated operator action can be accomplished before significant head loss due to strainer debris buildup materializes during the recirculation mode. The second case is for the design basis flow and debris laden strainer head loss. Debris laden head losses are based on the results of recently conducted flume tests.

Tables 10h-1 and 10h-2 summarize the pressure available to preclude the water from flashing because of the pressure drop across the screen face. The column titled Available Margin is the partial air pressure converted to feet of water plus the elevation pressure of the sump water above the highest point of the screen minus the pressure drop across the screen. The point of least margin or limiting point is the minimum temperature condition evaluated.

Table 10h-1 assumes a flow of 11,630 gpm across a clean strainer disk for the LPSI failure to trip case.

Table 10h-1 LPSI Failure to Trip

Temperature (°F)	Available Margin (ft. of water)
65	26.00
70	26.32
80	26.95
90	27.57
100	28.19
106.8	28.61
110	28.80
120	29.42
125	29.72
130	30.03
140	30.74
150	31.27
160	31.90
170	32.53
180	33.17
190	33.82
200	34.48
210	35.14
220	35.81
230	36.49
240	37.18

The submergence for a SBLOCA is 0.5 ft less than the LBLOCA. The available margin in feet of water may be reduced by 0.5 ft for a SBLOCA.

Table 10h-2 summarizes the pressure available to preclude the water from flashing because of the pressure drop across the debris laden screen face. This table assumes the design basis flow of 8,530 gpm across a debris laden strainer disk with chemical effects based on the Alden Labs integrated debris and chemical effects flume testing.

Table 10h-2 Debris Laden Margin

Temperature (°F)	Available Margin (ft. of water)
65	14.43
70	15.51
80	17.43
90	19.11
94.3	19.77
100	20.60
105.1	21.31
110	21.95
120	23.18
125	23.76
130	24.33
140	25.49
150	26.42
160	27.39
170	28.33
180	29.24
190	30.12
200	30.99
210	31.85
220	32.69
230	33.53
240	34.36

The submergence for a SBLOCA is 0.5 ft less than the LBLOCA. The available margin in feet of water may be reduced by 0.5 ft for a SBLOCA.

Assumptions used for the evaluation include:

1. It is assumed that the water in the sump is at saturation. This is a conservative assumption. The temperatures of the water in the containment sump are consistently lower than the temperature of the containment atmosphere. The pressure of the containment atmosphere is created by the steam produced during the LBLOCA and the partial pressure of air in containment. The temperature of the water in the containment

sump is produced by the hot water created by the LBLOCA and the water from the RWT pumped into containment during the injection phase. The water from the RWT is at a much lower temperature than the water created by the LBLOCA. Therefore, for the flashing evaluation, it is conservative to assume that the water in the sump and the steam in the containment atmosphere are at saturation.

2. Heating of the air in containment behaves as an ideal gas.
3. Post LBLOCA containment atmosphere water vapor and air are at approximately the same temperature.
4. Containment atmospheric pressure at plant elevation is 14.7 psia.
5. Relative humidity in containment is conservatively considered to be 100%.
6. Post LBLOCA containment pool temperature is conservatively assumed to be equal to containment atmosphere temperature.
7. The minimum partial pressure of air already in containment at the beginning of the postulated LBLOCA can be credited for the purposes of evaluating head loss margin to flashing at the ECCS/CSS sump screen debris bed.
8. Flow rates through the ECCS/CSS suction strainer debris bed are laminar with associated head losses varying with kinematic viscosity. The kinematic viscosity is the dynamic viscosity divided by the density.

The partial pressure of air already in containment was credited to prevent flashing. The partial pressure of air was determined using the most conservative assumptions. In accordance with the Technical Specifications (TS) the minimum containment pressure relatively to atmosphere at which the plant may be operated is -0.7 psig. It is conservative to assume that vapor pressure is at a maximum. In accordance with the TS the maximum containment temperature at which the plant may be operated is 120°F. The vapor pressure at this temperature is 1.69 psia. The initial containment pressure was thus determined, 14.7 psia – 0.7 psi – 1.69 psi = 12.31 psia. The partial pressure of air was then adjusted according to temperature over the entire range from 65°F to 240°F. Note that it is not even necessary to credit air heating to achieve significant margins.

RAI-10: The extrapolation of test results to parameters other than tested conditions is discussed in the supplemental response. It states that the strainer sector test head loss was scaled to the full sized strainer system based on velocity, kinematic viscosity, and bed thickness differences. State all extrapolations or scaling that was performed for the head loss evaluation. Provide the methodology for all scaling including the inputs and assumptions used.

i. The strainer submergence and vortexing evaluation included the volume of the Safety Injection Tanks (SIT) for the small break LOCA. It is possible for some small breaks that this volume would not be available for sump pool inventory. Provide a justification for the crediting of SIT volumes for sump pool level for all required breaks.

RAI-10i RESPONSE: As stated in the supplemental response dated June 30, 2008, the range of SBLOCA breaks includes those that require recirculation from the containment sump as well as those that permit the operators to depressurize the reactor coolant system (RCS) and initiate the shutdown cooling mode of decay heat removal, which does not require suction from the containment sump. Because the SBLOCA produces less debris, the debris load on the sump strainers is less than the design basis debris load. However, for the purpose of evaluating the sump strainer under SBLOCA conditions, it is conservatively assumed that the recirculation flow from the containment sump and the debris load are the same as the LBLOCA, and that the water level is that of the SBLOCA.

For breaks so small that RCS pressure can be maintained above the safety injection tank (SIT) pressure (thus preventing outflow) using high pressure safety injection (HPSI) pumps and/or charging pumps, system flows and debris generation are minimal as compared to the LBLOCA design basis. During the injection mode, this RCS pressure would be above the shutoff head of the LPSI pumps stopping inflow and would reduce flow from the HPSI pumps. Containment pressure would be insufficient to generate containment spray actuation signal (CSAS) or would be mitigated so rapidly as to allow early termination of the CSS pumps. With elevated RCS pressure, RCS cooling can be accomplished with steam generators and/or the shutdown cooling system. Considering such reduced flows from this very small break, the time to actuation of RAS is significantly delayed beyond the LBLOCA design of 20 to 30 minutes. 411,264 gallons is the minimum volume of water available from the RWT. With this volume, and even the equivalent of a 640 gpm (full HPSI pump) flow, it would take 10.7 hours to consume the RWT. This is sufficient time to cool the plant without switching to recirculation mode.

Even if it is assumed that SIT volumes do not discharge and spill through this break to the containment pool, and that recirculation mode is for some reason still required, the resultant post SBLOCA containment water level without SIT volume is approximately 22.84 ft versus 23.31 ft.

The strainer system high point vent on the manifold box is at elevation 22.69 ft which would be still submerged without SIT volume contributions. For these very small break flow rates, strainer approach velocities don't constitute a vortex issue and submersion precludes air ingestion.

In summary it can be concluded that a SBLOCA with full RCS blowdown and SIT discharge (with higher flows and debris) is the bounding SBLOCA case from a Generic Letter 2004-02 perspective, based on the following:

- Very small breaks involve limited injection flow and therefore extended delay before recirculation mode permitting RCS cooldown prior to recirculation
- Very small breaks ultimately involve limited recirculation flow (if required) and limited debris generation and transport.
- Strainers have significant submergence even without credit for SIT volumes in the post LOCA containment pool.