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Seabrook Station

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SBK-L-08136
Docket No. 50-443

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

Seabrook Station

Final Response and Notice of Completion for
NRC Generic Letter 2004-02
"Potential Impact of Debris Blockage on Emergency Recirculation
During Design Basis Accidents at Pressurized-Water Reactors"

References:

1. Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," September 13, 2004.

2. Letter from J. A. Stall (FPL) to U. S. Nuclear Regulatory Commission "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors," March 4, 2005.

3. Letter from V. Nerses (U. S. Nuclear Regulatory Commission) to M. E. Warner (FPL Energy Seabrook, LLC), "Seabrook Station, Unit 1 – Request for Additional Information (RAI) Related to Generic Letter 2004-02, Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized Water Reactors," June 3, 2005.

4. Letter from J. A. Stall (FPL) to U. S. Nuclear Regulatory Commission "Request for Additional Information - Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors," July 20, 2005.

5. Letter from J. A. Stall (FPL) to U. S. Nuclear Regulatory Commission "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors – Second Response," September 1, 2005.

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6. Letter from J. A. Stall (FPL) to U. S. Nuclear Regulatory Commission "Supplement to Response to NRC Generic Letter 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors," January 27, 2006.

7. Letter from G. E. Miller (U. S. Nuclear Regulatory Commission) to G. F. St. Pierre (FPL Energy Seabrook, LLC) "Seabrook Station, Unit No. 1, Request for Additional Information Re: Response to Generic letter 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," February 9, 2006.

8. Letter from C. T. Haney (U. S. Nuclear Regulatory Commission) to Holders of Operating Licensees for Pressurized Water Reactors, "Alternative Approach for Responding to the Nuclear Regulatory Commission Request for Additional Information RE: Generic Letter 2004-02," March 28, 2006.

9. Letter from G. E. Miller (U. S. Nuclear Regulatory Commission) to G. F. St. Pierre (FPL Energy Seabrook, LLC) "Seabrook Station, Unit 1 – Requested Extension of Completion Schedule for NRC Generic Letter 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors," April 11, 2006.

10. Letter from C. T. Haney (U. S. Nuclear Regulatory Commission) to Holders of Operating Licenses for Pressurized Water Reactors, "Alternative Approach for Responding to the Nuclear Regulatory Commission Request for Additional Information Letter Regarding Generic Letter 2004-02," January 4, 2007.

11. Letter from W. H. Ruland (U. S. Nuclear Regulatory Commission) to A. Pietrangelo (Nuclear Energy Institute), "Content Guide for Generic Letter 2004-02 Supplemental Responses," August 15, 2007.

12. Letter from W. H. Ruland (U. S. Nuclear Regulatory Commission) to A. Pietrangelo (Nuclear Energy Institute), "Revised Content Guide for Generic Letter 2004-02 Supplemental Responses," November 21, 2007.

13. Letter from W. H. Ruland (U. S. Nuclear Regulatory Commission) to A. Pietrangelo (Nuclear Energy Institute), "Supplemental Licensee Responses to Generic Letter 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," November 30, 2007.

14. Letter from J. A. Stall (FPL) to U. S. Nuclear Regulatory Commission "Request for Extension of Completion Date of the St. Lucie Unit 1, St. Lucie Unit 2 and Turkey Point Unit 3 Generic Letter 2004-02 Actions," December 7, 2007.

15. FPL Energy Seabrook, LLC letter SBK–L-08033, Supplemental Response to NRC Generic Letter 2004-02 "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," February 28, 2008.

The purpose of this submittal is to provide the FPL Energy Seabrook, LLC (FPL Energy Seabrook) final supplemental response to Generic Letter (GL) 2004-02 (Reference 1) and notification that the corrective actions to address Generic Safety Issue 191 are complete for Seabrook Station. The Nuclear Regulatory Commission (NRC) issued Reference 1 to request that addressees perform an evaluation of the emergency core cooling system (ECCS) and containment spray system (CSS) recirculation functions in light of the information provided in the GL and, if appropriate, take additional actions to ensure system functions.

Additionally, the GL requested addressees to provide the NRC with a written response in accordance with 10 CFR 50.54(f). The request was based on identified potential susceptibility of the pressurized water reactor (PWR) recirculation sump screens to debris blockage during design basis accidents requiring recirculation operation of ECCS or CSS and on the potential for additional adverse effects due to debris blockage of flow paths necessary for ECCS and CSS recirculation and containment drainage.

Reference 2 provided the initial FPL Energy Seabrook response to the GL. Reference 3 requested additional information regarding the Reference 2 response to the GL for Seabrook Station. Reference 4 provided the FPL Energy Seabrook response to Reference 3. Reference 5 provided the second of two FPL Energy Seabrook responses requested by the GL. In Reference 6, FPL Energy Seabrook requested a short extension for the completion of the corrective actions required by the GL for Seabrook Station until the Station spring 2008 refueling outage. This request for extension was approved in Reference 9. Reference 7 requested FPL to provide additional information to support the NRC staff's review of Reference 2, as supplemented by References 4 and 5.

Reference 8 provided an alternative approach and timetable that licensees may use to address outstanding requests for additional information (i.e., References 3 and 7). Reference 10 supplemented Reference 8 with the NRC expectation that all GL 2004-02 responses will be provided no later than December 31, 2007. For those licensees granted extensions to allow installation of certain equipment in spring 2008, the NRC staff expects that the facility response will be appropriately updated with any substantive GL corrective action analytical results or technical detail changes within 90 days of the change or outage completion. As further described in Reference 10, the NRC expects that all licensees will inform the NRC, either in supplemental responses to GL 2004-02 or by separate correspondence as appropriate, when all GSI-191 actions are complete.

Reference 11 describes the content to be provided in a licensee's final GL 2004-02 response that the NRC staff believes would be sufficient to support closure of the GL. Reference 12 revised the guidance provided in Reference 11 by incorporating minor changes, which were viewed by the NRC as clarifications. This final response was prepared using the guidelines of Reference 12.

Reference 13 authorized 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. Reference 15 provided the required response on February 28, 2008. In its response, FPL Energy Seabrook committed to provide a follow-on supplemental response within 90 days following the spring 2008 refueling outage. The refueling outage concluded on May 8, 2008, and this submittal provides the information to meet that commitment. Further, FPL Energy Seabrook has completed the planned corrective actions and confirmatory tests and analyses determined necessary to ensure that the recirculation functions under debris loading conditions will be in compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of GL 2004-02. The results of the corrective actions, tests, and analyses are presented in Attachment 1, which provides the final response to GL 2004-02. Revision bars in the attachment indicate information that has been updated since the February 28, 2008 response.

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

Should you have any questions regarding this letter, please contact Mr. Michael O'Keefe, Licensing Manager, at (603) 773-7745.

Very truly yours,

FPL Energy Seabrook, LLC.

Gene St. Pierre
Site Vice President

Attachments (1)

cc: S. J. Collins, NRC Region I Administrator
G. E. Miller, NRC Project Manager, Project Directorate I-2
W. J. Raymond, NRC Senior Resident Inspector

FPL Energy
Seabrook Station

AFFIDAVIT

SEABROOK STATION UNIT 1

Facility Operating License NPF-86
Docket No. 50-443

Final Response and Notice of Completion for
NRC Generic Letter 2004-02
"Potential Impact of Debris Blockage on Emergency Recirculation
During Design Basis Accidents at Pressurized-Water Reactors

I, Gene F. St. Pierre, Site Vice President of FPL Energy Seabrook, LLC hereby affirm that the information and statements contained within this supplemental response to Generic Letter 2004-02 are based on facts and circumstances which are true and accurate to the best of my knowledge and belief.

Sworn and Subscribed
before me this
4 **day of** August, **2008**

[signature]
Notary Public

[signature]
Gene St. Pierre
Site Vice President

MICHAEL D. O'KEEFE
MY COMMISSION EXPIRES FEB. 13, 2013
NOTARY PUBLIC
NEW HAMPSHIRE

Attachment 1

Final Updated (Follow-on) Response and Notice of Completion for
NRC Generic Letter 2004-02
"Potential Impact of Debris Blockage on Emergency Recirculation
During Design Basis Accidents at Pressurized-Water Reactors

UPDATED (FOLLOW-ON) RESPONSE TO GENERIC LETTER 2004-02

Topic 1: Overall Compliance

FPL Response

The responses to GL 2004-02 that were submitted to the NRC on September 1, 2005 (September 1 response) and February 28, 2008 (February 28 response) were based on work in progress and the information that was available at the time of the submittals.

Subsequently, FPL Energy Seabrook (FPLE) has completed the planned corrective actions and confirmatory tests and analyses that had been determined necessary to ensure that the ECCS and CSS recirculation functions under debris loading conditions will be in compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of GL 2004-02. The results of the completed planned corrective actions, tests and analyses are presented in this follow-on response.

Additional information to support the staff's evaluation of Seabrook Unit 1 compliance with the regulatory requirements of GL 2004-02 was requested by the NRC in a "Request for Additional Information" (RAI) dated February 9, 2006 (NRC Letter to FPL (G. F. St. Pierre), Seabrook Station, Unit 1, Request for Additional Information RE: Response to Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized-Water Reactors" (TAC No. MC4716), February 9, 2006). Each RAI question is addressed in this response. The RAI question (and specific RAI response) is identified by the RAI question number in the following format: **[RAI ##]**, where ## is the RAI question number.

Confirmation that there is sufficient NPSH margin, including chemical effects, is provided in the responses to NRC Topics 3.f, *Head Loss and Vortexing*, and 3.g, *Net Positive Suction Head Available (NPSH).* Conservatisms include; (a) assuming one single failure to maximize the flow through the strainer, and a second single failure to maximize the debris load, (b) assuming that 100% of the particulates, miscellaneous and latent debris, and chemical precipitant were transported to the strainers, (c) assuming the minimum sump water level, and (d) using a conservative test termination factor of 1/0.95.

Confirmation that vortexing and flashing will not occur is provided in the response to NRC Topic 3.f, *Head Loss and Vortexing.*

Confirmation that, overall, the ECCS and CBS systems remain capable of fulfilling their required safety related functions in the presence of debris-laden fluid following a LBLOCA is provided in the response to NRC Topic 3.m, *Downstream Effects – Components and Systems.* Conservatisms include; (a) use of a 50 micron particulate size, and (b) assuming that all debris was in the sump pool and eroded (to the extent it would be after 30 days) at the start of recirculation.

Confirmation that the maximum fuel cladding temperature remains well below the 800 °F criterion is provided in the response to NRC Topic 3.n, *Downstream Effects – Fuel and Vessel.*

In summary, the information presented in this response confirms that the ECCS and CBS recirculation functions under debris loading conditions, and calculated core temperature following a LOCA, are in compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of GL 2004-02.

Topic 2: General Description of and Schedule for Corrective Actions

FPL Response

Subsequent to the September 1 response, FPL Energy Seabrook (FPLE) requested a short extension to permit completion of corrective actions associated with GL 2004-02 during outage OR12 which was scheduled for the spring of 2008 (FPL to NRC Letter L-2006-028, "Supplement to Response to NRC Generic Letter 2004-02, 'Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors,' " January 27, 2006). The NRC approved the extension request in a letter dated April 11, 2006 (NRC Letter to FPL Energy Seabrook (G. F. St. Pierre), Seabrook Station, Unit No. 1, Requested Extension of Completion Schedule for NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized-Water Reactors" (TAC No. MC4716), April 11, 2006). As part of the extension request, FPLE committed to, and installed, debris interceptors during outage OR11 (fall 2006) to mitigate the effects of debris generated by a postulated LOCA. The installed debris interceptors are described in the response to NRC Topic 3.j, *Screen Modification Package*. The remaining identified corrective actions, which were planned for outage OR12 (spring 2008), have been completed and are discussed below. Enhancements to programmatic controls are described in the responses to NRC Topics 3.h, *Coatings Evaluation* and 3.i, *Debris Source Term.*

The original sump screens have been completely replaced with strainers that provide a strainer surface area of approximately 2,412 ft^2 in each sump. The new strainers are passive (i.e., the strainers do not have any active components or rely on backflushing). The strainers are described in the response to NRC Topic 3.j, *Screen Modification Package*

Additional debris interceptors have been installed on the scuppers in the bioshield wall to further reduce the debris that can be transported to the sump strainers from a postulated LOCA. The scupper debris interceptors are described in the response to NRC Topic 3.j, *Screen Modification Package.*

Walkdowns have been completed in the Seabrook Unit 1 containment specifically for the purposes of characterizing latent and miscellaneous (foreign) debris.

Cable tray adhesive labels have been removed to reduce the miscellaneous debris that could be generated by labels that fail due to a postulated LOCA. The cable tray label reduction is described in the response to NRC Topic, 3.d, *Latent Debris.*

The full-scale sector combined chemical effects tests have been completed. The test results are described in the responses to NRC Topics 3.f, *Head Loss and Vortexing*, 3.g, *Net Positive Suction Head (NPSH)*, and 3.o, *Chemical Effects.*

The downstream effects analyses have been completed. The analysis results are described in the responses to NRC Topics 3.m, *Downstream Effects – Components and Systems*, and 3.n, *Downstream Effects – Fuel and Vessel.*

Programmatic controls and procedures ensure that the design basis debris source term will not be exceeded. The programmatic controls and procedures are described in the response to NRC Topic 3.i, *Debris Source Term*.

Topic 3.a: Break Selection

FPL Response
In agreement with the staff's Safety Evaluation (SE) of Nuclear Energy Institute (NEI) 04-07, the objective of the break selection process was to identify the break size and location which results in debris generation that will maximize the head loss across the containment sump strainers. Breaks were evaluated based on the methodology in NEI guidance document NEI 04-07 as modified by the staff's SE of NEI 04-07.

The following specific break location criteria were considered:

- Breaks in the reactor coolant system with the largest amount of potential debris within the postulated ZOI,
- Large breaks with two or more different types of debris, including breaks with the most variety of debris,
- Breaks in areas with the most direct path to the sump,
- Medium and large breaks with the largest potential particulate debris to insulation ratio by weight, and
- Breaks that generate an amount of fibrous debris that, after transport to the sump strainers, could form a uniform "thin bed".

[RAI 34] All Reactor Coolant System (RCS) piping and attached energized piping was considered for potential break locations. Feedwater and main steam piping was not considered for potential break locations because ECCS in recirculation mode is not required for Main Steam or Feedwater line breaks.

[RAI 33] Only one type of insulation (Nukon) will be affected by a bounding break at Seabrook Unit 1. This means that any break location will yield a similar debris mix. Therefore, inside the bioshield, the discrete approach described in Section 3.3.5.2 of the staff's SE of NEI 04-07 was used to identify limiting break locations based on the debris source term and the transport potential. The staff's SE of NEI 04-07 notes that the concept of equal increments is only a reminder to be systematic and thorough. As stated in the staff's SE of NEI 04-07, 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 that is affected.

Inside the bioshield, breaks in the hot leg (29-inch ID), crossover leg (31-inch ID), cold leg (27½-inch ID), pressurizer surge line (14-inch nominal), RHR hot leg recirculation line (12-inch nominal), and cold leg safety injection line (10-inch nominal) were considered. The RHR, safety injection and other piping in the same general area inside the bioshield are smaller diameter than the reactor coolant lines. Therefore, breaks in these lines are bounded by breaks in the reactor coolant lines. The crossover leg has the largest diameter and produces the largest ZOI. A break in the loop 4 crossover leg was selected for analysis because it is close to the containment sump. A break in the loop 4 hot leg was also selected for analysis because it is close to the sump, and is also near loop 1 where it will generate debris from both loops. A break in the loop 3 crossover leg was selected for analysis because the pressurizer and associated piping are on this loop.

A hot leg or cold leg line break at the reactor pressure vessel (RPV) was also considered. The RPV is covered with Transco reflective metal insulation (RMI) insulation. This break would affect the reactor insulation and the insulation on the RCS lines adjacent to the break up to the penetrations. However, this debris would fall to the bottom of the reactor vessel cavity, and would not have a transport path to the sump. In addition, the debris interceptors would further reduce the possible quantity of RMI that could be transported to the sump. Finally, Transco RMI is less detrimental to sump performance than fiber debris, and the amount of debris would be bounded by a hot or cold line break elsewhere in the line. Therefore, a hot leg or cold leg break at the RPV would not be bounding and was not analyzed.

Outside the bioshield, breaks were considered in the RHR recirculation lines. The RHR recirculation lines are of smaller diameter than the RCS piping. Therefore, inside the bioshield, a break in these lines would be bounded by the reactor coolant loops. However, the RHR recirculation lines travel outside the bioshield before the second isolation valve, directly above the sumps. Therefore breaks in these lines were selected for analysis in order to include a break outside the bioshield. A break in line RC-58 produced the most debris among potential break locations outside the bioshield.

The postulated break locations were as follows:

- S1 Loop 4 hot leg at the base of the steam generator (29-inch ID)
- S2 Loop 4 crossover leg at the base of the steam generator (31-inch ID)
- S3 Loop 3 crossover leg at the base of the steam generator (31-inch ID)
- S4 RHR recirculation line RC-58 outside the bioshield (12-inch nominal)

Break S3 generated the greatest quantity of debris. Therefore, it was selected for the strainer design basis.

Topic 3.b: Debris Generation/Zone of Influence (ZOI) (excluding coatings)

FPL Response

The debris generation calculation used the methodologies of Regulatory Guide 1.82, Rev. 3, NEI 04-07 and the staff's SE of NEI 04-07. However, there have been changes in the input to the analyses since the September 1 response.

Debris specific ZOIs were used in the debris generation calculation. The ZOIs for insulation, except for jacketed Nukon, were obtained from Table 3-2 of the staff's SE of NEI 04-07. Refinements to the ZOIs that were provided in NEI 04-07 are based on test data (i.e., ZOI for jacketed Nukon). The ZOI for each debris type is discussed below.

The ZOI used for unjacketed Nukon is 17.0D, which was obtained from Table 3-2 of the NRC staff's SE of NEI 04-07. The ZOI for jacketed Nukon is 7.0D. The ZOI reduction from 17.0D to 7.0D for jacketed Nukon is supported by tests documented in WCAP-16710-P, "Jet Impingement Testing to Determine the Zone of Influence (ZOI) of Min-K and NUKON® Insulation for Wolf Creek and Callaway Nuclear Operating Plants," Rev. 0, October 2007.

The ZOI used for Transco RMI is 2.0D, which was obtained from Table 3-2 of the NRC staff's SE of NEI 04-07.

The updated debris generation calculation makes use of two assumptions related to non-coating debris generation.

Assumption 1

Supporting members fabricated from steel shapes (angles, plates) are installed to provide additional support for RMI on equipment such as reactor coolant pumps, Steam Generators and Pressurizer. It is assumed that, as a result of the postulated pipe break, these supporting members will be dislodged from the equipment, and may be bent and deformed, but will not become part of the debris that may be transported to the sump.

Assumption 2

In the September 1 response, it was noted that an analytical process was used that conservatively overstated the quantity of debris from insulation by 5-15%. That analytical process has been completely replaced, and the debris quantity is no longer overstated. However, 100 ft^3 has been added to the Nukon insulation volume results for margin. In addition, a uniform factor of 1.1 is applied to the ZOI that is used for calculating piping insulation volumes to account for minor variances such as insulation around valves, irregularities in the as-installed configuration.

The quantities of debris and the ZOI for each debris type are provided in Table 3.b-1 below.

Table 3.b-1: Destruction ZOI and Break Comparison

Debris Type	Destruction ZOI	Break S1 (Note 1)	Break S2 (Note 1)	Break S3 (Note 1)	Break S4 (Note 1)
Nukon (Total) Jacketed Unjacketed	 7.0D 17.0D	988.21 ft^3	1024.82 ft^3	1233.14 ft^3	92.70 ft^3
Insulation Jacketing	7.0D	2397.61 ft^2	2417.77 ft^2	2938.89 ft^2	172.24 ft^2
Qualified Coatings (Note 2) Concrete Steel (Note 3) Steel (Note 3)	 4.0D 4.0D 10.0D	 1.32 ft^3 1.80 ft^3 3.45 ft^3	 1.32 ft^3 1.80 ft^3 3.45 ft^3	 1.32 ft^3 1.80 ft^3 3.45 ft^3	 0.24 ft^3 0.50 ft^3 0.00 ft^3
Unqualified Coatings - Total	N/A	22.36 ft^3	22.36 ft^3	22.36 ft^3	22.36 ft^3
Latent Debris (Note 4) (15% Fiber, 85% Particulate)	N/A	40.7 lbm	40.7 lbm	40.7 lbm	40.7 lbm
Foreign Materials (Note 5)	N/A	39.8 ft^2	39.8 ft^2	39.8 ft^2	39.8 ft^2

Notes:
1. Break locations are discussed in the response to NRC Topic 3.a, *Break Selection*.
2. The destruction ZOIs for qualified coatings is discussed in the response to NRC Topic , 3.h, *Coatings Evaluation*.
3. A ZOI of 4D was applied to those qualified steel coatings that were tested and passed the test criteria for use of a 4D ZOI. A ZOI of 10D was applied to qualified steel coatings that were not included in the test for applicability of a 4D ZOI.
4. The measured quantity of latent debris was 40.7 lbm. However, the quantity of latent debris used in the transport analysis was conservatively increased to 200 lbm.
5. Strainer Foreign Materials ("Sacrificial Area") include the surface area of all signs, placards, and similar materials in containment In the February 28 response it was noted that a corrective action had been initiated to reduce the quantity of labels during outage OR12 (spring of 2008), and that the results of the corrective action would be reported in this follow-on response. The quantity reported in Table 3.b-1 incorporates the results of the reduction program. However, the sacrificial area dedicated to foreign materials is conservatively retained as 150 ft^2.

Topic 3.c: Debris Characteristics

FPL Response

[RAI 35] The potential sources of debris in the Seabrook containment are reflective metal insulation (RMI), coatings, Nukon and Nukon insulation jacketing, latent and miscellaneous debris. The RMI is located on the reactor vessel, and the limiting breaks are not close enough to the reactor vessel to generate RMI debris. Therefore the debris in the Seabrook containment is made up of coating debris, Nukon, Nukon jacketing, latent and miscellaneous debris.

All coating debris was modeled as small fines.

The Nukon (fiber) transport was modeled in two stages for the purposes determining the strainer debris load and head loss. As discussed in the response to 3.e: *Debris Transport*, Stage 1 covers the time period up to the start of recirculation, and Stage 2 covers the time after the start of recirculation. Stage 1 modeled fiber transport to the first encountered debris interceptor and does not consider debris size. Stage 2 modeled fiber transport from the debris interceptors to the sump strainers and does consider debris size. The size distributions used for the fiber transport in the Stage 2 transport model are provided in Table 3.c-1 below.

Because the debris interceptors prevent insulation jacketing from reaching the sump strainers, the debris characteristics for insulation jacketing were not required for the transport analysis, and therefore were not developed.

The technical basis for the surface areas of signs, placards, tags, tape, etc is provided in the response to NRC Topic 3.d, *Latent Debris.*

The specific surface area, S_V, is a parameter that is used in the NUREG/CR-6224 head loss correlation. The head loss across the strainers was determined by testing, not the NUREG/CR-6224 correlation. Therefore, the specific surface area was not calculated or used. The head loss determination is described in the response to NRC Topic 3.f, *Head Loss and Vortexing.*

The bulk densities used in the analyses and tests are provided in Table 3.c-2 below.

Table 3.c-1: Fiber Debris (Nukon) Size Distribution

Transport Stage	Category	Size Percentage
Stage 1	17.0D ZOI	
	Fines	8%
	Small Pieces	25%
	Large Pieces	32%
	Intact	35%
Stage 1	7.0D ZOI	
	Fines	25%
	Small Pieces	75%
	Large Pieces	0%
	Intact	0%
Stage 2	Fines and Small Pieces	100%

Table 3.c-2: Bulk Densities Used For Sector Tests

Debris Type	Surrogate	Bulk density
Nukon Fiber	Nukon Fiber	2.4 lbs/ ft^3
Particulates	Silicon Carbide	94 lbs/ ft^3

Topic 3.d: Latent Debris

FPL Response
The bases and assumptions related to latent and miscellaneous debris, and the resulting quantities used for analyses and testing, have been updated since the September 1 and February 28 responses. In the September 1 response it was noted that the quantity of latent debris was an assumed value in lieu of applied survey results, and that the sacrificial area for miscellaneous debris was an estimated value. Subsequently, walkdowns have been completed in the Seabrook Unit 1 containment specifically for the purposes of characterizing latent and miscellaneous (foreign) debris. These walkdowns utilized the guidance in NEI 02-01 and the staff's SE of NEI 04-07.

The methodology used to estimate the quantity and composition of latent debris in the Seabrook containment is that of the staff's SE of NEI 04-07, Section 3.5.2.2. Samples were collected from eight surface types; floors, containment liner, ventilation ducts, cable trays, walls, equipment, piping and grating. Where feasible, for each surface type a minimum of (4) samples were collected, bagged and weighed to determine the quantity of debris that was collected. A statistical approach was used to estimate an upper limit of the mean debris loading on each surface. The horizontal and vertical surface areas were conservatively estimated. The total latent debris mass for a surface type is the upper limit of the mean debris loading multiplied by the conservatively estimated area for that surface type, and the total latent debris is the sum of the latent debris for each surface type.

Based on the walkdown data, the quantity of latent debris in the Seabrook Unit 1 containment is estimated to be 40.7 pounds. However, for conservatism, the strainer test was based on 200 pounds of latent debris. The latent debris composition is assumed to be 15% fiber and 85% particulate in agreement with the staff's SE of NEI 04-07.

The walkdown for miscellaneous (foreign) debris was performed for the purpose of identifying and measuring plant labels, stickers, tape, tags and other debris. The estimated quantity of miscellaneous debris in the Seabrook Unit 1 containment, based on the walkdown, is provided in Table 3.d-1 below. In the February 28 response it was noted that a corrective action had been initiated to reduce the quantity of labels during outage OR12 (spring of 2008), and that the results of the corrective action would be reported in this follow-on response. The quantity reported in Table 3.d-1 incorporates the results of the reduction program and results in a total transportable (non-glass) area of 39.80 ft^2. However, the sacrificial area dedicated to foreign materials is conservatively retained as 150 ft^2.

Table 3.d-1: Estimated Miscellaneous (Foreign) Debris in Containment

Item	Containment Total
Labels, Stickers, Tape, etc.	28.15 ft^2
Tags, Placards, etc.	11.649 ft^2
Glass (containment lighting)	241.775 ft^2
Adhesive	0.00217 ft^3

Topic 3.e: Debris Transport

FPL Response
The Seabrook Unit 1 containment is a "mostly uncompartmentalized containment" as described in Section 3.6.2 of NEI 04-07. Debris interceptors are utilized to limit the quantity of debris that reaches the strainers by trapping debris and allowing the remaining debris more time to settle. Debris interceptors have been installed in all but one of the bioshield access openings, and have been installed on one end of eighteen (18) scuppers in the bioshield wall to prevent debris bypassing the annulus debris interceptors via the scuppers. The bioshield access opening farthest from the sumps is left open so that flow is assured from the inner annulus to the outer annulus, regardless of the debris accumulation on the other bioshield debris interceptors. The debris interceptors (including locations) and sump strainers are described in the response to NRC Topic, 3.j, *Screen Modification Package*.

[RAI 41] In the September 1 response it was noted that debris transport would be analyzed using the computational fluid dynamics (CFD) based methodology outlined in NEI 04-07. Subsequently, for the purposes of determining the strainer debris load and head loss, it was decided to use a two stage approach that is based on a combination of analysis and testing. Stage 1 covers the time period up to the start of recirculation (i.e., pool fill-up). This stage modeled fiber transport up to the first encountered debris obstacle. Stage 2 covers the time after the start of recirculation. This stage modeled fiber transport from the debris interceptors to the sump strainers. Transport of particulates, latent, and miscellaneous debris is discussed separately below. The results of the transport analyses used for the strainer debris load and head loss are summarized in Table 3.e-1.

The Stage 1 analysis considered three main debris transport modes of NEI 04-07 for insulation debris: (1) blowdown transport, (2) washdown spray transport and (3) pool fill-up transport. No credit was taken for debris settling in the Stage 1 analyses.

Due to the relative simplicity of the transport analysis, logic trees were not required, and were not used in the Stage 1 analysis. For insulation debris, the blowdown transport analyses used the approach in Appendix VI of the staff's SE of NEI 04-07. For mostly uncompartmentalized containments, Section 3.6.3.2 of NEI 04-07 states that all RMI debris (small and large) is conservatively postulated to fall to the containment floor. Although NEI 04-07 does not specifically state that all fiber debris is assumed to fall to the containment floor, it was conservatively modeled as such. Thus all LOCA generated debris was modeled as falling to the containment floor.

The initial insulation debris dispersion in the blowdown transport analysis was modeled using an approach similar to that in Section VI.3.3.2.1 of the staff's SE of NEI 04-07. However, because of the Seabrook containment design, it was acceptable to base the insulation debris dispersion on floor area instead of compartment volume. The basement floor inside containment was divided into pie shaped regions at 45° intervals, and the area of each region was computed. Each region was then assigned a baseline value based on its fraction of the whole area, and a weighting factor for each break that was based on the region's proximity to each break. These values were then used to determine the initial debris dispersion for each break.

A Stage 1 washdown spray transport analysis was not required or performed, because, as stated above, it was conservatively assumed that all LOCA generated insulation debris was deposited on the floor of the containment during blowdown.

In the Stage 1 pool fill-up analysis, due to velocities inside the bioshield being as high as 2 to 3 m/s, all insulation debris was assumed to transport to a debris interceptor in the bioshield doorways during pool fill-up with one exception. That exception is the transport pathway through the single bioshield doorway opening that is not blocked by a debris interceptor. Large and intact debris that is transported through the open doorway is assumed to remain at rest outside this doorway in the Stage 1 transport analysis. All other debris that is transported through this doorway is assumed to transport to the nearest debris interceptor in the annulus outside the bioshield.

Sequestration of debris in inactive volumes during pool fill-up is considered as part of the Stage 1 analysis. The quantity of fine debris sequestered in inactive volumes is limited to 15% in accordance with the staff's SE of NEI 04-07.

The Stage 2 analyses modeled fiber transport during recirculation. The starting point was the fiber distribution generated for the bounding break in the Stage 1 transport analysis. Simulated bioshield fiber transport tests were run to determine the fraction of the fiber that is transported through the doorway that does not contain a debris interceptor. The results of the tests are that 70% of the fiber is transported through the doorway for single train operation and 53% of the fiber is transported through the doorway for dual train operation. The Stage 2 transport analyses were then performed for two recirculation flow cases; 13,180 gpm and 8,050 gpm. In both cases the velocity was based on the minimum water level. These flow velocities were then correlated with the test velocities to determine the amount of fiber held up at each debris interceptor. The effectiveness of the debris interceptors with regard to retaining fiber was determined by testing in a 20-foot flume with approach velocities that ranged from 0.252 ft/sec to 0.517 ft/sec.

Particulates, latent and foreign debris were modeled separately. For the purpose of establishing the debris load used for strainer head loss testing it was assumed that all particulate, latent and foreign debris was transported to the strainer, and, in addition, the latent debris load was assumed to be 200 pounds. (This is significantly larger than the value that was determined based on walkdown data, 40.7 lbm. (See the response to NRC Topic 3.d, *Latent Debris.*)

In the Stage 1 analysis, debris from qualified coatings was transported using the same methodology and weighting factors as the insulation debris described above. The locations of many unqualified sources were identified from the unqualified coatings log. Where the location of an unqualified coating source was able to be determined, the debris from that source was distributed to the appropriate debris interceptor and/or the sump strainer. The remainder of the unqualified coating debris was distributed equally between all the debris interceptors and sump strainers. Latent debris consists of 85% particulate and 15% fiber. The particulate latent debris was modeled as being divided between the inner and outer annulus based on the area ratio of the two, and then was distributed equally between the debris interceptors and sump strainers in the inner and outer annuli respectively. Foreign material was modeled with an initial distribution of 75% in the outer annulus (which is where the sump strainers are located), and distributed equally between the outer annulus debris interceptors and the sump strainers. The 25% of the foreign debris that was initially distributed to the inner annulus was distributed equally between the debris interceptors at the inner annulus doors.

For the case where both trains are operating, the debris is assumed to be distributed equally between the two sumps. For the case where a single train is operating the debris is assumed to be transported to the operating train's strainer.

Table 3.e-1: Test Debris at Sump Strainer Modules for Limiting Case

Constituent	Quantity Generated	Quantity at Strainer (Note 1)	
		8050 gpm	13,180 gpm
Fiber			
Nukon	1233.14 ft^3	35.35 ft^3	117.93 ft^3
Latent Fiber (30 lbm) (Note 3)	12.5 ft^3	12.50 ft^3	6.25 ft^3
Total		47.85 ft^3	124.18 ft^3
Insulation Jacketing (Note 2)	2938.89 ft^2	0.00 ft^2	0.00 ft^2
Coatings			
Qualified - Concrete	1.32 ft^3		
Qualified - Steel	5.25 ft^3		
Unqualified - All	22.36 ft^3		
Total	28.93 ft^3	28.93 ft^3	14.46 ft^3
Latent Particulate (Note 3)	170 lbm	170 lbm	85 lbm
Foreign Materials (Note 4)	39.8 ft^2	150 ft^2	75 ft^2

Notes:
1. When both trains are operating it is assumed that the total debris load is equally divided between both sumps. In addition, the quantity of insulation fiber transported to the strainers included the effects of the decreased velocity for single train flow during recirculation, which was not applied to latent fiber or particulate debris. (i.e., 100% of particulate debris was transported to the strainers).
2. Insulation jacketing can not pass beyond the first encountered debris interceptor.
3. The measured quantity of latent debris was 40.7 lbm. However, the quantity of latent debris in the Stage 2 transport analysis was conservatively increased to 200 lbm, with a breakdown of 85% particulates and 15% fiber.
4. Foreign material is actually a "sacrificial area" and a transport fraction is not applicable. In the February 28 response it was noted that a corrective action had been initiated to reduce the quantity of labels during outage OR12 (spring of 2008), and that the results of the corrective action would be reported in this follow-on response. The quantity reported in Table 3.e-1 incorporates the results of the reduction program. However, the sacrificial area dedicated to foreign materials is conservatively retained as 150 ft^2.

Topic 3.f: Head Loss and Vortexing

FPL Response

A piping schematic of the ECCS and containment/reactor building spray systems is provided in Figure 3.f-1. A description of the strainers and debris interceptors, including the capability to accommodate thin bed effects, is provided in the response to NRC Topic 3.j, *Screen Modification Package.*

[RAI 37] [RAI 40] The strainers are expected to be fully submerged from the initiation of recirculation through the duration of the event. At the minimum LBLOCA water levels, the submergence of the strainer modules is > 7 inches and at the minimum SBLOCA water levels the submergence is > 4 inches.

The absence of vortex formation and air ingestion was confirmed by the full-scale sector tests where no vortexing or air entrainment was observed during the tests. Initial clean sector vortex tests were performed with a submergence of 2½ inches (which is less than the minimum submergence of > 4 inches), and a test velocity that was equal to or greater than the expected strainer approach velocity. Additional vortex testing was conducted prior to adding the debris in the full-scale sector combined chemical effects test. Prior to adding the debris, the water level was adjusted to the top of the strainer and gradually lowered to 12 inches below the top of the strainer. No vortexing or air entrainment was observed during the reduced water level portion of the test or at any other time during the course of the head loss testing. Analyses to evaluate the possibility of vortex formation and air ingestion close to the pump suction line were not performed because vortex formation and air ingestion did not occur at the top of the strainer, and the suction intake centerline is an additional 7 feet below the top of the strainer.

The strainer head loss is based on the sector head loss tests that were run specifically for Seabrook Unit 1 by Continuum Dynamics, Inc (CDI). The tests used a full-scale test sector. Therefore, the head loss associated with traveling downward through the debris bed was captured in testing, and all other issues with scaling were eliminated. The test sector modeled one sector of the strainer from the vertical centerline of the one disk set to the vertical centerline of the adjacent disk set. The test tank simulated the plenum sitting on the sump floor, and a mixing tank simulated the containment floor. The tests modeled a series of debris bed thicknesses, including a thin bed, to determine the limiting strainer debris head loss.

The head loss, including chemical effects, was determined by integrated fiber, particulate and chemical effects tests. The test configuration was the same for each test. The chemical effects and non-chemical effects testing used the same methodology. However, the chemical precipitant debris load being tested was added in stages during the chemical effects tests to determine the limiting debris load. All tests were performed in this sequence of steps: first, the pump is brought up to speed and clean head loss is established. Next, particulate is added. Then, shredded fiber is added. The surrogate for the chemical precipitant, aluminum oxyhydroxide, is added in increments and the ΔP is measured after each incremental addition. The fiber is shredded twice to ensure an adequate distribution of fines. All testing is done with wetted debris added to the mixing tank to aid in mixing. Testing was performed using essentially neutral water at 65 °F to 85 °F and the maximum calculated quantities of fibrous debris, particulate debris and chemical precipitant.

[RAI 39] The new strainer system has a surface area of approximately 2,412 ft^2 in each sump, which can accommodate the maximum debris load from the bounding break discussed in the response to NRC Topic 3.a, *Break Selection*. The strainer capability to accommodate a thin bed is discussed in the response to NRC Topic 3.j, *Screen Modification Package*. The head loss is made up of the strainer head loss, the water level drop due to the debris interceptors, and the plenum head loss. The bounding case is single train operation because of the higher flow through the strainer.

[RAI 40] To develop a circumscribed bed, the gap must fill and overflow with fiber and particulate. The strainer can hold over 668 ft^3 of fiber while the maximum amount transported to the strainer is 124.18 ft^3. Therefore there is insufficient fiber to form a circumscribed bed.

The water level drop due to the debris interceptors is from the hydraulic loss associated with the flow rate and the height of the debris interceptor. In effect, the debris interceptors can act as a weir dam. The water level drop has been calculated to be 0.48 inch at 8,050 gpm (single train).

The plenum head loss is due to the hydraulic losses associated with flow going through turns and other accelerations in the plenum. The plenum head loss has been calculated to be 3.323 inches at 8,050 gpm (one train with full flow through one strainer).

The clean strainer plate head loss is taken from the sector head loss testing at the approach velocity and is not scaled.

The scaled debris head loss uses a scale factor of 1.0 and a test termination factor of 1/0.95. The scaling methodology and absence of boreholes are discussed below.

Assumptions, margins and conservatisms used in establishing the head losses are:

- A temperature of 212 °F
- The test used a single train flow rate of 8050 gpm and a dual train flow rate of 13180 gpm.
- The debris transport analysis assumed 200 lbm of latent debris vs. the calculated quantity, which was 40.7 lbm.
- The strainer sacrificial area for miscellaneous debris is assumed to be 150 ft^2, with an additional margin of 50 ft^2. The actual miscellaneous debris is 39.8 ft^2.
- The combined debris/chemical effects strainer plate loss has a test termination factor of 1/0.95 (~5% increase) to account for the very small possibility that the head loss could increase beyond the termination criteria of 1% change per 30 minute interval.

The resulting head loss for the strainer system, including chemical effects, is provided in Table 3.f-2.

[RAI 36] Near-field settling was not credited in the sector tests. The steps taken to minimize near-field effects included directing the flow return along the bottom of the mixing tank to help suspend debris in the mixing tank before the mix of debris and water entered the test tank. In addition, at least two (2) motor driven mixers were used. The materials listed in Table 3.f-1 were used to represent the Seabrook Unit 1 debris in the test.

Temperature and viscosity were not used to scale the results of the head loss tests to actual plant conditions. This is because debris strainer head loss is scaled based on velocity, viscosity and bed thickness differences only when there is laminar flow. If there is turbulent flow the head loss is scaled by the velocity squared. A review of the debris beds morphology shows the debris beds had open areas. The open areas result in turbulent flow through the strainer perforated plates. Therefore the loss would be scaled by the velocity squared, and temperature and viscosity would not be used. Since the test and plant velocities are the same, the scaling factor is 1.0. The absence of boreholes was confirmed by examining the disassembled test sector after each test.

Flashing is a concern at Seabrook Unit 1 when the water is assumed to be at 212 °F at 1 atmosphere. When credit is not taken for plant over pressurization, the water level above the strainer must be greater than the head loss through the debris bed and into the plate. This is 0.61 inches for the clean condition head loss and 3.92 inches for the total debris/chemical effects head loss. The minimum submergence is greater than 4 inches for both the LBLOCA and SBLOCA. However, for the purpose of demonstrating that flashing will not occur, the vapor pressure of water at 260 °F plus 1 atmosphere of air is added to the minimum strainer submergence and compared to the test results. The adjusted flashing criterion is 1500 inches, which is much greater than the head loss.

Table 3.f-1: Sector Test Debris Materials

Debris Type	Material	Density	Manufacturer
Nukon	Nukon Fiber (shredded twice)	2.4 lb/ft^3	Performance Contracting, Inc
Coatings	Silicon Carbide (~ 10 micron dia)	94 lb/ft^3	Electro Abrasives
Latent Debris Fiber Particulate	 Nukon Fiber (shredded twice) Silicon Carbide (~ 10 micron dia)	 2.4 lb/ft^3 94 lb/ft^3	Performance Contracting, Inc. Electro Abrasives
Particulates	Silicon Carbide (~ 10 micron dia)	94 lb/ft^3	Electro Abrasives
Chemical Precipitant	Aluminum Oxyhydroxide (AlOOH)	0.092 lbs/gal	N/A

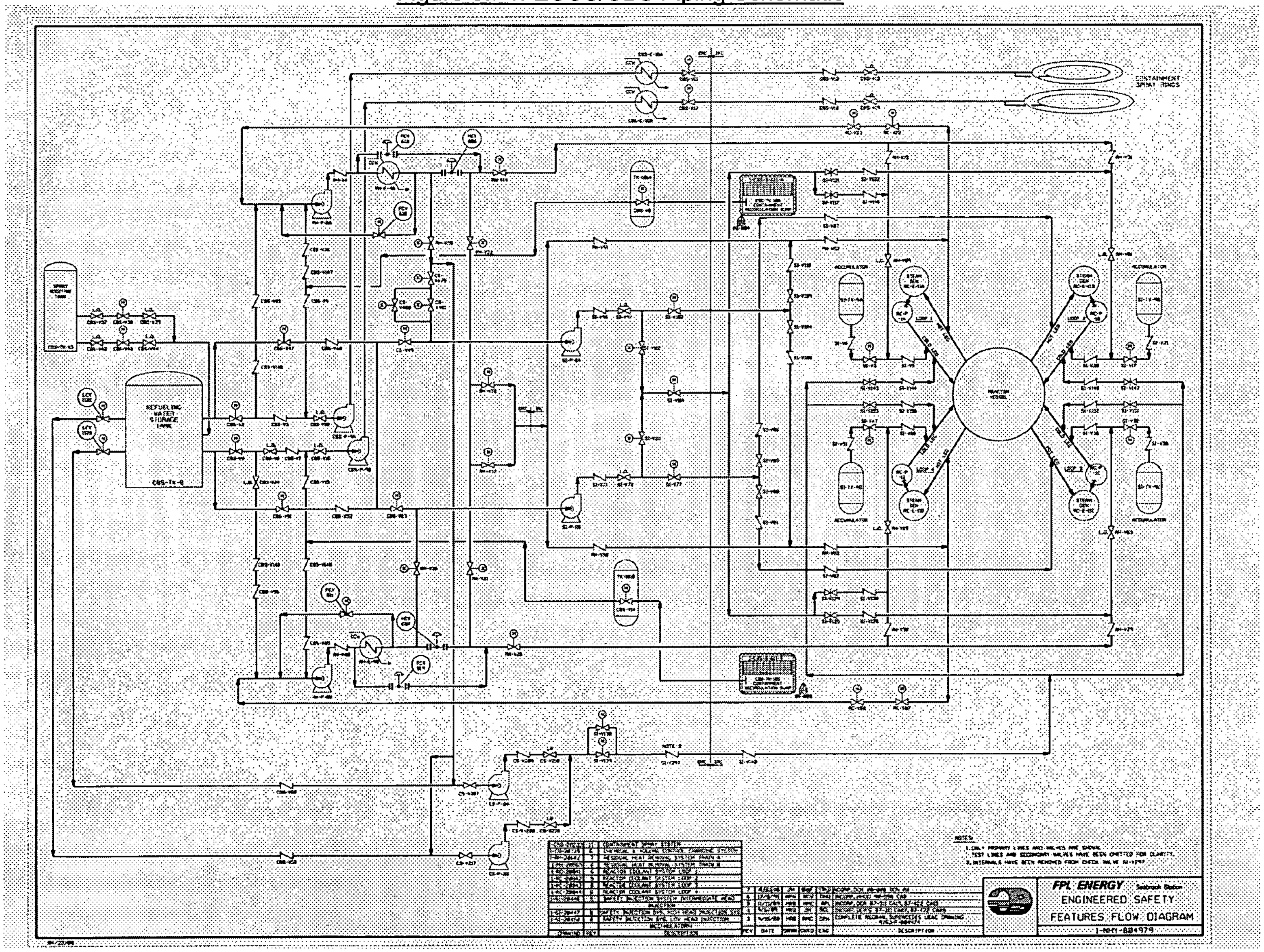
Table 3.f-2: Strainer Head Loss Summary

Condition	Flow Rate (gpm)	Total Debris Head Loss With Termination Factor (in)	Clean Strainer Plate Head Loss (in)	Bounding Plenum Head Loss (in)	Debris Interceptor Head Loss (Note 1) (in)	Total Head Loss (in)
Debris Laden	8,050	3.48	0.44	3.32	0.48	7.72
Clean	8,050	N/A	0.44	3.32	0.48	4.24

Notes:

1. The debris interceptor head loss is the water level drop downstream of the debris interceptors due to the weir dam effect.

Figure 3.f-1: ECCS/CBS Piping Schematic



Topic 3.g: Net Positive Suction Head Available (NPSH)

FPL Response

This response to NRC Topic 3.g, has been reorganized from the February 28, 2008 submittal to correspond to the latest NRC submittal guidance, "Revised Content Guide for Generic Letter 2004-02 Supplemental Responses, November 2007." The relocated text has not changed, and is shown below in italics.

The maximum design flow rate is 8050 gpm per sump for single train operation and 6,590 gpm per sump (13,180 gpm total) for dual train operation. The maximum flow per sump is the sum of RHR pump flow (4,388 gpm) and the CBS pump flow (3,657 gpm). As noted below, the CC and SI pumps operate in "piggyback" mode during recirculation, so they are included in the total.

The sump pool temperature range is as follows.

- *Maximum Temperature:............................... 260 °F*
- *Design Temperature.................................... 212 °F*
- *Long Term Temperature.............................. 160 °F*

The minimum sump water level for the LBLOCA is 3.01 feet at 212 °F and 2.93 feet at 160 °F. The minimum sump water level for the SBLOCA is approximately 3 inches less.

The maximum integrated ECCS and CBS flows were calculated for both cold leg and hot leg recirculation conditions following a large-break LOCA (LBLOCA) using RELAP5YA. The hydraulic system model includes nominal RHR, SI, CCP, and CBS pump performance curves and realistic system frictional and form losses. Steady-state boundary (operating) conditions are selected so as to calculate maximum system flows.

The NPSH required is taken from RHR and CBS pump curves for the design basis flow for each pump. Pump flow rates were rounded up when calculating the NPSH required, which increases NPSH required (e.g., using the exact flow rate for the CBS pump would reduce NPSH required by approximately 0.1 ft).

The sump water level is conservatively based on the following assumptions and considerations.

a. Water Sources
    - *Minimum water transferred from the RWST*
    - *Minimum pressurizer water*
    - Minimum accumulator tank water
    - Minimum spray additive tank water
b. Water Hold Up
    - *Water held up in the refueling canal*
    - *Water held up in spray piping*
    - *Water held up in suspended droplets*
    - Water held up in containment cavities
c. Other Effects

- The water level is reduced by 0.13 ft to account water lost due to analyzed ECCS leakage outside containment

The additional volume of the debris interceptors and new strainers is not credited. Also, as discussed in the response to NRC Topic 3.I, Screen Modification Package, the design and layout of the debris interceptors ensures that they do not create choke points or otherwise prevent water from reaching the ECCS sumps after recirculation is initiated. For example, although the "weir dam" effect discussed in the response to NRC Topic 3.f, Head Loss and Vortexing, can affect NPSH, it does not affect the water volume or average water level.

Following a large break LOCA (LBLOCA) both trains of the Residual Heat Removal (RHR) Pumps, Centrifugal Charging (CC) Pumps, Safety Injection (SI) Pumps and Containment Building Spray (CBS) Pumps are automatically started (Operation of the CBS pumps is initiated by high containment pressure. Operation of the other pumps is initiated by the safety injection signal.) Recirculation is not initiated until at least 26 minutes after the LBLOCA. Recirculation is initiated by the Refueling Water Storage Tank (RWST) low-low level signal. Upon receipt of this signal, the RHR and CBS pumps are automatically re-aligned to take suction from the recirculation sumps. The CC pumps and SI pumps are then manually re-aligned to take suction from the RHR pumps discharge ("piggyback" mode). (The CC pumps are aligned to the RHR train A pump and the SI pumps are aligned to the RHR train B pump.) All pumps continue to operate in the recirculation mode until no longer required.

Following a small break (SBLOCA) it is possible that all pumps could be automatically started as described above for the LBLOCA. This would result in full ECCS and CBS flows. However, the debris loading on the strainer would be lower than the design basis debris load from an LBLOCA.

The effects of two single failures were conservatively included in the analyses. The first single failure assumes that one RHR pump fails to start at the initiation of injection, which maximizes the flow through a single sump. The second single failure in effect assumes that one RHR pump fails after the start of recirculation (after the injection phase is completed), which maximized the debris load on the strainers. This scenario is non-mechanistic, but was used to maximize both flow and debris load.

The following key assumptions were used in the calculation of these margins.

- *Fluid vapor pressure equals the containment atmospheric pressure (i.e., credit is not taken for the partial pressure of air in containment).*
- *Strainer head loss is based on the integrated chemical effects/debris tests described in the response to NRC item 3.f, Head Loss and Vortexing.*

Under these conditions, the minimum available NPSH margin for the LBLOCA, including chemical effects is 0.16 feet. As discussed above, the SBLOCA water level is approximately 3 inches less than the LBLOCA water level. However, the SBLOCA debris load is expected to be considerably less than the 124.18 ft^3 used for the LBLOCA. These two effects are compensatory, and therefore, it is expected that the

NPSH margin for the SBLOCA will be similar. For example, the minimum available margin for 48 ft^3 of debris and a 3 inch lower water level is 0.11 ft.

As discussed above, the flows were rounded up for NPSH required. Using the exact value would increase the minimum NPSH margin for the LBLOCA from 0.16 ft to 0.26 ft, and for the SBLOCA from 0.11 ft to 0.21 ft.

Topic 3.h: Coatings Evaluation

FPL Response
Coatings are classified as qualified or unqualified. The qualified coating systems used in the Seabrook Unit 1 containment are listed in Table 3.h-1 below.

Table 3.h-1 Qualified Coatings in the Seabrook Unit 1 Containment

Substrate	Application	Coating Product	Applied Thickness (mils)
Steel			
3 coat system	1st Coat	Keeler & Long #6548 Epoxy White	8
	2nd Coat	Keeler & Long #6548 Epoxy White Primer – tinted	4
	3rd Coat	Keeler & Long #D-1 Series Epoxy Hi-Build Enamel	6
2 coat system A	1st Coat	Keeler & Long #6548 Epoxy White Primer or tinted	12
	2nd Coat	Keeler & Long #D-1 or #E-1Series Epoxy Enamel	6
2 coat system B	1st Coat	Ameron Dimetcote E-Z II Inorganic Zinc Primer	6
	2nd Coat	Ameron Dimetcote 66 Epoxy	9
1 coat system A	1st Coat	Keeler & Long #6548 Epoxy White Primer	18
1 coat system B	1st Coat	Keeler & Long #4500 Epoxy Self Priming Surface Enamel	18
1 coat system C	1st Coat	Ameron Dimetcote 6 Inorganic Zinc Silicate	12 mils
Concrete Floor			
4 coat system	1st Coat	Keeler & Long #4129 Epoxy Clear Curing Compound	1.5
	2nd Coat	Keeler & Long #6548 Epoxy White Primer	7
	3rd Coat	Keeler & Long #6548 Epoxy White Primer - tinted	7
	4th Coat	Keeler & Long #D-1 Series Epoxy Hi-Build Enamel	6
Concrete Wall			
3 coat system	1st Coat	Keeler & Long #4129 Epoxy Clear Curing Compound	1.5
	2nd Coat	Keeler & Long #4000 Epoxy Surfacer	50

Substrate	Application	Coating Product	Applied Thickness (mils)
	3rd Coat	Keeler & Long #D-1 Series Epoxy Hi-Build Enamel	6
2 coat system	1st Coat	Keeler & Long #4129 Epoxy Clear Curing Compound	1.5
	2nd Coat	Keeler & Long #4500 Epoxy Self Priming Surfacing Enamel	20

[RAI 30] For Seabrook Unit 1, the bounding analyzed LOCA case generated sufficient fiber to form a fiber bed approximately 0.67" thick. Consistent with the staff's SE of NEI 04-07 for thin fiber bed cases, all coating debris is treated as particulate. ElectroCarb black silicon carbide with 10-micron particle diameter was used as a surrogate for coatings because it matches the bulk density and the particle size of the majority of the coating debris.

The post-LOCA paint debris transport is described in the response to NRC Topic 3.e, *Debris Transport.* Selected features of the treatment of qualified and unqualified coatings in the determination of coating debris that reaches the sump strainers have been updated since the September 1 response. These changes are discussed individually below.

The qualified coating ZOI in the September 1 response for Seabrook Unit 1 was 10D. The ZOI for qualified coatings that have been tested has subsequently been reduced to 4D. The 4D ZOI is based on testing that was completed at the St. Lucie Plant during February of 2006. For qualified coating systems that have not been tested, the ZOI remains at 10D.

[RAI 29] A description of the test, test data and evaluation of the test results were previously provided to the NRC staff for information on July 13, 2006 (FPL Letter L-2006-169, R. S. Kundalkar (FPL) to M.G. Yoder (NRC), "Reports on FPL Sponsored Coatings Performance Tests Conducted at St. Lucie Nuclear Plant," July 13, 2006). The evaluation of the test results confirms that a 4D ZOI is applicable to the in-containment qualified coating systems at Seabrook Unit 1. As stated in the test plan, heat and radiation increase coating cross linking, which may enhance the coating physical properties. Therefore, since artificial aging, heat or irradiation to the current plant conditions could enhance the physical properties and reduce the conservatism of the test, the test specimens were not aged, heated or irradiated.

The coating thicknesses in the September 1 response were assumed to be 3 mils of inorganic zinc primer plus 6 mils of epoxy (or epoxy-phenolic) top coat for qualified coatings and 3 mils of inorganic zinc (IOZ) for unqualified coatings. Subsequently the analyses have been updated, and now use the maximum specified application thickness for each coating system.

The coating area in the ZOI in the September 1 response was assumed to be equal to the surface area of the ZOI. Subsequently, the updated debris generation calculations calculate the quantity of qualified coatings for each break by using the concrete and steel drawings to determine the amount of coating that will be within the ZOI for each break. Coatings that are shielded from the jet by a robust barrier are not included in the total. The calculated volume of qualified steel coating is then increased by 10% to account for small areas of additional items such as piping, pipe/conduit/HVAC/cable tray supports, stiffener plates, ladders, cages, handrails and kick plates.

The estimated quantity of unqualified/failed coatings in the September 1 response was 14 ft^3. With the changes discussed above, the estimated quantity of unqualified/failed coatings is now 28.93 ft^3.

Subsequent to the September 1 response, the process for controlling the quantity of degraded qualified coatings in containment has been enhanced to ensure that the quantity of degraded qualified coatings does not exceed the design basis.

[RAI 25] The current program for controlling the quantity of unqualified/degraded coatings includes two separate inspections during each refueling outage. The first inspection takes place at the beginning of every refueling outage when all areas and components from which peeling coatings have the potential for falling into the reactor cavity or recirculation sumps are inspected. The second inspection takes place at the end of every refueling outage when the condition of containment coatings is assessed using guidance from EPRI Technical Report 1003102 "Guidelines On Nuclear Safety-Related Coatings," Revision 1, (Formerly TR-109937). All accessible coated areas of the containment and equipment are included in the second inspection.

The initial coating inspection process is a visual inspection. The acceptability of visual inspection as the first step in monitoring of Containment Building coatings is validated by EPRI Report No. 1014883, "Plant Support Engineering: Adhesion Testing of Nuclear Coating Service Level 1 Coatings," August 2007. Following identification of degraded coatings, the degraded coatings are repaired per procedure if possible. For degraded coatings that are not repaired, areas of coatings determined to have inadequate adhesion are removed. The assessment is by means of additional nondestructive and destructive examinations as appropriate. The acceptability of the as-left coating condition for restart is addressed in a condition report.

Topic 3.i: Debris Source Term

FPL Response

Portions of this response to NRC Topic 3.i, were originally provided in the February 28, 2008 submittal in the section titled "Foreign Material Control Programs." This relocated text has not changed and is shown below in italics.

Information related to programmatic controls for foreign materials was provided to the NRC in previous submittals. Such information was provided in letter L-2003-201 which responded to Bulletin 2003-01, and most recently in letter L-2005-181, which responded to GL 04-02. In general, the information related to programmatic controls that was supplied in these responses remains applicable. However, since the September 1 response, modifications, tests and walkdowns have been completed, and these have been used to inform and update the programmatic controls that support the new sump strainer system design basis.

The results of the completed walkdowns to assess the quantities of latent and miscellaneous debris are discussed in the response to NRC Topic 3.d, Latent Debris. These walkdowns were conducted without any preconditioning or pre-inspections. Consequently, the debris found during the walkdowns is characteristic of approximately 16 years of operation under the existing housekeeping programs. Given the small quantity of latent and miscellaneous debris after 16 years of operation under the current housekeeping program combined with the label reduction program, it is concluded that the current housekeeping programs are sufficient to ensure that the new strainer system design bases will not be exceeded.

All physical modifications to equipment or structures within the scope of the Design Change Control program must be approved and controlled by a design change process. The design change processes control permanent changes, temporary alterations and temporary modifications. The design change processes ensure that installation details, testing requirements and applicable design inputs such as design bases, regulatory requirements, codes and standards are correctly translated into specifications, calculations, procurement documents, drawings, procedures or instructions.

The procedure that controls temporary alterations in support of maintenance requires that they be evaluated under the Maintenance Rule, 10 CFR 50.65 (a) (4).

Programmatic controls to control the introduction of foreign material into containment include tracking all non-bulk items brought into containment as part of the containment entry procedure. In addition, the containment entry procedure has been updated to require that <u>any</u> aluminum to be taken into containment must be evaluated prior to entry.

The surveillance procedure that inspects the containment recirculation sumps has been extensively revised. The procedure now contains the following provisions:

- Verification that **no** loose debris or fibrous material that could degrade into loose debris is present in accessible areas of the containment after containment integrity has been set. Loose debris is defined as any item or residue that may affect the operation of the containment sump.

- Bubbling or chipping paint is **unacceptable** and shall be reported immediately for evaluation of system operability.

Additional programmatic controls related to coatings are provided in the response to NRC Topic 3.h, Coatings Evaluation.

The fourth debris source term refinement discussed in Section 5.1 of NEI 04-07, "Modify Other Equipment Or Systems," was utilized. This refinement consists of removing selected labels on cable trays and wire ways to ensure that the area of miscellaneous debris at the sump strainers (sacrificial area) will be no more than 150 ft^2. The results of the label removal program are discussed in the response to NRC Topic 3.d, *Latent Debris.*

<u>Topic 3.j: Screen Modification Package</u>

<u>FPL Response</u>

The original sump screens have been replaced with new strainer modules during outage OR12 (spring 2008). Debris interceptors had already been installed to reduce the quantity of debris that can be transported to the strainer modules.

[RAI 32] The new strainers and debris interceptors are passive (i.e., there are no active components and the strainers do not utilize backflushing).

The new strainer system uses the General Electric disk strainers. The installed strainer surface area is approximately 2,412 ft^2 for each sump. The strainer perforations are nominal 1/16th-inch diameter round holes (0.0625 inch diameter opening). The strainer modules use an arrangement of parallel, rectangular strainer disks that have exterior debris capturing surfaces of perforated plate covered with woven wire mesh. The wire mesh decreases the head loss across the strainer plates by breaking up debris beds. Each strainer disk, constructed of two plates, has an open interior to channel disk flow downward to the strainer plenum. The disks are mounted on the discharge plenum, which channels disk flow to the suction piping. All strainer components, with the possible exception of bolts and anchors, are fabricated from stainless steel.

Each strainer module interfaces with its associated ECCS inlet pipe. The ECCS inlet pipe is located inside a strainer "dog house" which is directly open to the strainer plenum. However, there is no physical connection between the strainer and the ECCS inlet pipe. The sides of the "dog house" are made of the same perforated plate/wire cloth composite design as the disks. The roof of the dog house is equipped with cover plates similar to those used in the rest of the plenum.

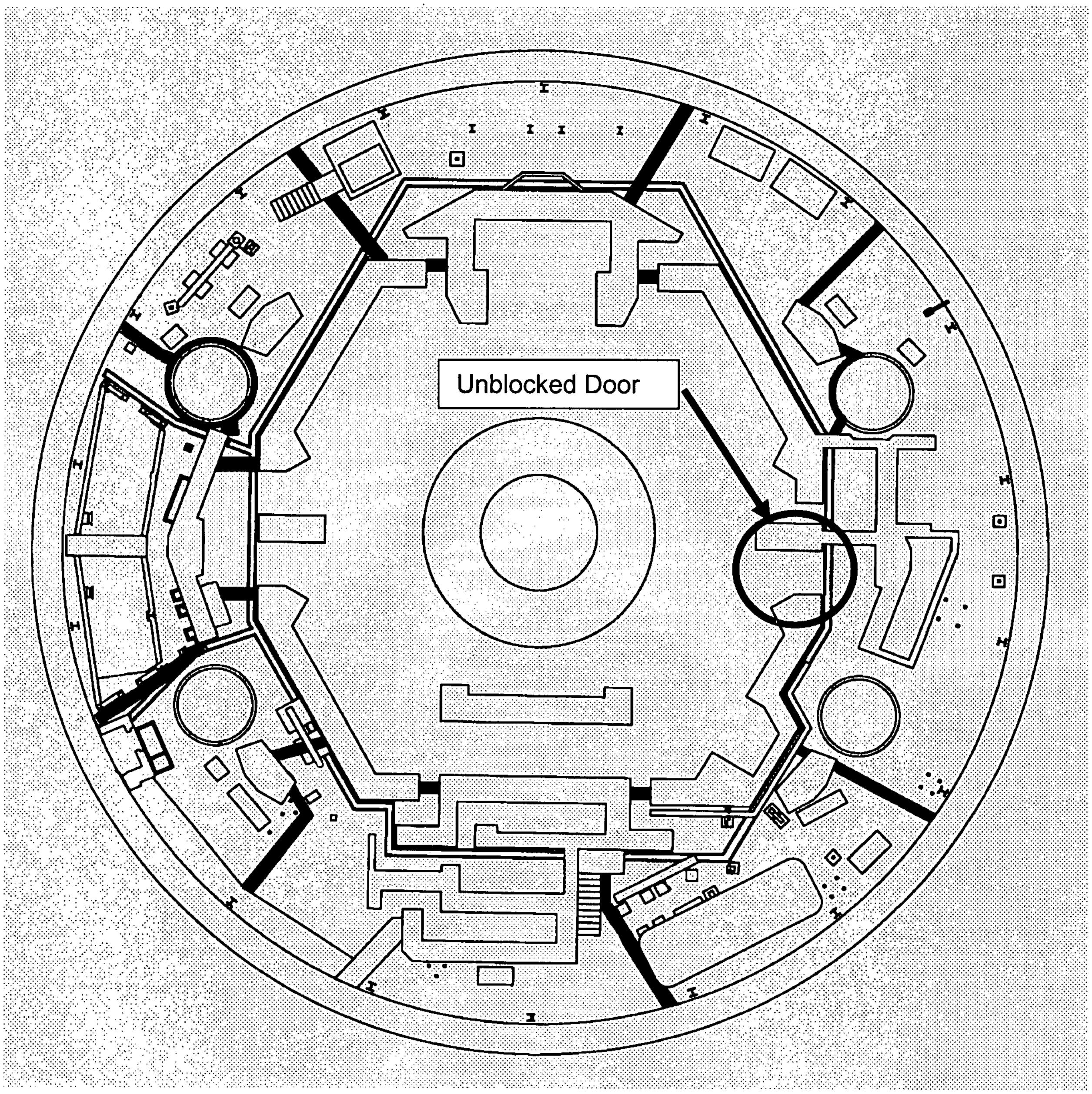
For Seabrook Unit 1, the analyzed LOCA cases generated sufficient fiber to form a thin fiber bed. However, the debris plate and the pitch between disks allow the GE Plenum Strainer to mitigate thin bed effects. The capability of the strainer system to accommodate the maximum mechanistically determined debris volume has been confirmed by a combination of testing and analysis. The volume of debris at the screen is discussed in the response to NRC Topic 3.e, *Debris Transport.*

The capability to provide the required NPSH with this debris volume is discussed in the response to NRC Topic 3.g, *Net Positive Suction Head (NPSH).* The capability to structurally withstand the effects of the maximum debris volume is discussed in the response to NRC Topic 3.k, *Sump Structural Analysis.*

Four types of debris interceptors have been installed in the Seabrook containment.

- Bioshield Debris Interceptors
  Bioshield debris interceptors are installed in the passageways in the bioshield wall except for the east-most door. (This is to ensure that there is at least one unobstructed passageway for water from the break to the annulus.) The locations are shown in Figure 3.j-1. They are approximately 6-feet tall and have hinged gates (doors) where needed and feasible to allow for personnel and equipment access.
- Annulus Debris Interceptors
  Annulus debris interceptors are located radially around the containment building in the outer annulus area between the bioshield wall and the containment wall. The locations are shown in Figure 3.j-1. They are typically 17½ inches tall and have a hinged gate at each location to allow for personnel and equipment access. Most annulus debris interceptors also have an 18 inch wide horizontally oriented debris interceptor panel mounted on top.
- Accumulator Skirt Debris Interceptors
  Where an annulus debris interceptor adjoins the support structure for an accumulator, (accumulator skirt) the skirt serves as part of the debris interceptor span. The location is shown in Figure 3.j-1. Debris interceptor panels are installed on the accumulator skirt openings.
- Bioshield Scupper Debris Interceptors
  Bioshield scupper debris interceptors have been installed on one end of eighteen (18) scuppers in the bioshield wall to prevent debris bypassing the annulus debris interceptors via the scuppers. The scuppers are small passageways (approximately 4-inches square) through the bioshield wall that allow water leaking inside the bioshield to pass through the wall to the floor drains located outside the bioshield. Installing debris interceptors on the scupper openings prevents potential fiber bypass around the annulus debris interceptors.

With the exception of the Bioshield scupper debris interceptors, the debris interceptors are constructed from stainless steel bar grating overlaid with a stainless steel wire cloth with 0.38-inch square openings. The scupper debris interceptors, although of a different construction (because of their smaller size) have a similar hole size, 0.375-inch nominal diameter round holes.



Debris Interceptor ▬▬▬
The unblocked door does not have a debris interceptor.
The debris Interceptors on the bioshield scuppers are not shown.

Figure 3.j-1: Seabrook Unit 1 Debris Interceptor Locations

Topic 3.k: Sump Structural Analysis

FPL Response
The previous sump strainers have been completely replaced by new strainer modules and debris interceptors.

Each strainer assembly and each debris interceptor is a passive unit (i.e., there are no active components and the strainers do not utilize backflushing). (They are described in the response to NRC Topic 3.j, *Screen Modification Package.*

The Seabrook Unit 1 containment has two independent sumps. Each sump has its own strainer module consisting of twenty (20) strainer disk sets. Each disk set is composed of four (4) individual strainer disks with two side by side and an additional two mounted above the lower disks. The disks are bolted vertically to each other and to a bottom plenum by means of flanged connections. The disk sets are bolted to those in adjoining vertical planes by means of connector plates attached to the flanges. All strainer components are fabricated from stainless steel and the anchorage details are designed to accommodate thermal expansion. Therefore there are no internal component thermal stresses.

The trash rack function is incorporated into the debris interceptors and strainer module design. Separate trash racks are not required.

The strainers and their components were analyzed using a detailed ANSYS structural analysis model. The strainers and their supports are designed and analyzed using the ASME BP&V Code, Section III, Subsection NC, Class 2 (for the components) and Subsection NF (for the supports) as a guide. The capability of the strainer perforated plate disks as structural members is based on an equivalent plate approach similar to that presented in ASME III, Appendix A, Article A-8000. ASME Service Level B allowables are used as a guide for the stress evaluation of both normal and accident conditions. Thus, ASME III Subsection NF paragraph NF-3251.2 is used for Class 2 plate and shell type components; and NF-3350 for Class 2 linear type supports. For bolts, the stress limits of NF-3324.6, increased by values provided in Table NF-3225.2-1, are used. Welds are evaluated per paragraph NF-3324.5. Expansion anchors are evaluated using the ultimate capacity values with a safety factor of four (4).

The new strainer modules are in the same location as the original strainers, which is outside the bioshield wall. The new strainers are not subject to missiles, pipe whip or jet impingement.

The strainer structural loads and load combinations are summarized in Table 3.k-2 and the structural qualification results are summarized in Table 3.k-4 below.

The debris interceptors and supports are fabricated from stainless steel. The bioshield and annulus debris interceptors are constructed from stainless steel bars (1-inch by 3/16-inch) overlaid with stainless steel wire cloth and are supported by a combination of vertical floor-mounted support posts and wall mounts. The accumulator skirt debris interceptors are similar in design, but are bolted to the accumulator skirt without physically modifying the skirt. The scupper debris interceptors are constructed from perforated stainless steel sheet approximately 5.34-inch by 4.38-inch and 0.12-inch thick.

The structural adequacy of the debris interceptors and their components was confirmed using hand analysis methods. Seismic adequacy was confirmed using an equivalent static analysis. The debris interceptor acceptance criteria used the guidance in the AISC Manual of Steel Construction, 9th Edition and the ASME BP&V Code Section II, part D. Expansion anchors were evaluated using the ultimate capacity values with a safety factor of four (4).

The locations of the debris interceptors have been analyzed for susceptibility to missiles, jet impingement and pipe whip. Postulated missiles will not strike the debris interceptors. None of the bioshield or annulus debris interceptors are in the path of a postulated pipe whip or jet spray.

The debris interceptor structural loads and load combinations are summarized in Table 3.k-3 below.

Table 3.k-1: Structural Load Symbols

Symbol	Load Definition
D	Dead Load, in air
D'	Dead Load Debris Weight plus Hydrodynamic Mass (Submerged)
L	Live Load
T_o	Normal Operating Thermal Load
T_a	Accident Thermal Load
E_{o1}	Earthquake Load, OBE in air
E_{o2}	Earthquake Load, OBE in water
E_{ss1}	Earthquake Load, SSE in air
E_{ss2}	Earthquake Load, SSE in water
P_{cr}	Differential (Crush) Pressure

Table 3.k-2: Strainer Loads and Load Combinations

Load	Strainer Load Combination
1	$D + L + E_{o1}$
2	$D + L + T_o + E_{o1}$
3	$D + L + T_o + E_{ss1}$
4	$D' + L + T_a + E_{o2} + P_{CR}$
5	$D' + L + T_a + E_{ss2} + P_{CR}$

Table 3.k-3: Bounding Debris Interceptor Loads and Load Combinations

Load	Bioshield and Annulus DI Load Combinations (Notes 1-4)
1	D + L
2	D + L + E_{o1}
3	0.63 (D + E_{ss1}) + P_{CR}

Notes:

1. Thermal expansion stresses, T_a, are negligible and therefore, are not included.
2. The differential pressure load is 500 lbs per panel. This is the hydrodynamic force during pool fill-up or recirculation.
3. The hydrodynamic effects during an SSE, E_{ss2}, are negligible and therefore, are not included.
4. Live load, L, is 0.0 for debris interceptors.

Table 3.k-4: Strainer Module Stress Ratio Results

Component	Stress/Load Value	Allowable	Ratio to Allowable
Disks			
Perforated Plate	28.6 ksi	31.0 ksi (2S)	0.92
Wire Cloth	25.8 ksi	31.0 ksi (2S)	0.83
Frame/Rib	8.5 ksi	12.3 ksi (1.33 x $0.4S_Y$)	0.69
Weld of Perf to End Channels	5.2 ksi	12.3 ksi (1.33 x $0.4S_Y$)	0.42
Weld of Perf to Flanges	4.8 ksi	12.3 ksi (1.33 x $0.4S_Y$)	0.39
Resistance Weld of Wire Cloth	36 lbs	750 lbs	0.05
Weld of Ribs to Frame	8 ksi	12.3 ksi (1.33 x $0.4S_Y$)	0.65
Disk to Disk Bolting	9.3 ksi	23.3 ksi ($0.345S_U$)	0.40
Disk to Plenum Bolting	3.3 ksi	23.3 ksi ($0.345S_U$)	0.14
Disk Connector Plates	10.2 ksi	23.05 ksi (1.33 x $0.75S_Y$)	0.44
Connector Plate Bolting (max single shear)	19.96 ksi	19.96 ksi ($0.1426S_U$)	1.00
Connector Plate Bolting (max double shear)	14.6 ksi	19.96 ksi ($0.1426S_U$)	0.73
Separator Wall Anchorage Detail			
Weld/bolt of Disk Flange to Intermediate Plate	17.3 ksi	23.3 ksi ($0.345S_U$)	0.74
Intermediate Plate	3.7 ksi	23.1 ksi	0.16
1-1/8 inch Diameter Stud	91.2 ksi	102.8 ksi (S_Y)	0.89
Clip Brackets	14.5 ksi	23.1 ksi	0.63
Weld of Brackets to Base Plate	3.5 ksi	12.3 ksi (1.33 x $0.4S_Y$)	0.29
Hilti Base Plate	13.7 ksi	23.1 ksi	0.59
Hilti Expansion Anchors-Tension	2.8 kips	3.1 kips	0.91
Supporting Base Frame and Plenum Roof			
Frame Tubing	14.6 ksi	31.0 ksi (2S)	0.47
Tube Splice Connection	7.8 ksi	9.63 ksi ($0.1426S_U$)	0.81
Plenum Roof Plates	<19.3 ksi	31.0 ksi (2S)	<0.62
Plenum Roof Bolts	15.3 ksi	19.96 ksi ($0.1426S_U$)	0.77

Component	Stress/Load Value	Allowable	Ratio to Allowable
Floor Anchorage Detail			
Weld of Gusseted Bracket to Tube Member	2.7 ksi	12.3 ksi (1.33 x $0.4S_Y$)	0.22
Shoulder Bolts – Tension/shear interaction	N/A	N/A	0.52
Hilti Base Plate	17.8 ksi	23.1 ksi	0.77
Hilti Expansion Anchors – Tension/Shear	N/A	N/A	0.96
"Dog House"			
Side Walls	See "Disks"	N/A	N/A
Eastern End Plate	30 ksi	31.0 ksi (2S)	0.97
Eastern End Plate Clip Connection	10.1 ksi	23.05 ksi (1.33 x $0.75S_Y$)	0.44
East to West Section Bolted Connections	11.5 ksi	19.96 ksi ($0.1426S_U$)	0.58
Connections to Base Frame	15.6 ksi	19.96 ksi ($0.1426S_U$)	0.78
ECCS WALL Connections			
Interface Plate	15.9 ksi	31.0 ksi (2S)	0.51
Clamp Bolt	23.1 ksi	23.3 ksi ($0.345S_U$)	0.99
Hilti Expansion Anchors	2.1 kips	3.13 kips	0.66
Catch Basin Pan			
Hilti Expansion Anchors-Shear	107 lbs	1.26 kips	0.09

Topic 3.l: Upstream Effects

FPL Response

[RAI 38] Water in the refueling canal is conservatively assumed to be held up. As a result, the water sequestered in the refueling canal is excluded from the determination of the minimum recirculation water level and the NPSH calculations that use the recirculation water level as an input parameter. However, the existing procedure for entering Mode IV ensures that the refueling cavity drain path is open.

The debris interceptor design and layout ensures that the debris interceptors do not create new choke points. The debris interceptors in the annulus are designed so that there is a nominal 9 inches of clearance between the top of the debris interceptor and the minimum water level. The east-most bioshield doorway does not have a debris interceptor to ensure that there is at least one completely unobstructed pathway for water to flow from the break to the outer annulus. The unblocked doorway is noted on Figure 3.j-1.

With regard to other potential choke points, the walkdowns that were conducted during refueling outage OR09 (October 2003) surveyed recirculation and drainage flow paths for equipment or structures that could potentially prevent water from reaching the sumps. The flow path survey included curbs, ledges, gates, tool boxes, etc., but because of the timing, did not cover the debris interceptors. However, the information for all other flow paths that was provided in the September 1 response remains applicable. It is repeated here for convenience.

> "A walkdown and analysis of the Seabrook containment was performed to assess potential chokepoints in the path from the RCS loops to the ECCS sump, including gates and screens. The walkdown confirmed that there are no potential chokepoints that would adversely affect operation of the ECCS and CBS in the recirculation mode or cause the sump water level and associated NPSH to be less than the design basis values."

Topic 3.m: Downstream Effects – Components and Systems

FPL Response

In the September 1 response it was noted that, at that time, the downstream evaluations identified instrumentation and twenty two (22) components that required further evaluation. These evaluations have now been completed.

[RAI 31] Component downstream analyses have been completed using the methodologies of WCAP-16406-P Revision 1 (WCAP-16406-P "Evaluation of Downstream Sump Debris Effects in Support of GSI-191, Revision 1, August 2007).

The analysis of downstream effects at Seabrook primarily follows that set forth in WCAP-16406-P, Revision 1. A summary of the application of those methods is provided below with a summary and conclusions of the downstream effects calculations performed. Any exceptions or deviations from the NRC-approved methodology are noted below. The methodology, summary, and conclusions are provided as related to downstream component blockage and wearing, the subjects addressed by Topic 3.m.

Blockage/Plugging of ECCS and CBS Flowpaths and Components

GL 2004-02 Requested Information Item 2(d)(v) addresses the potential for blockage of flow restrictions in the ECCS and CBS flowpaths downstream of the sump screen, while item 2(d)(vi) refers to plugging of downstream components due to long-term post-accident recirculation. The difference in requirements is that blockage refers to the instantaneous blockage of flowpath components due to the maximum debris size that passes the recirculation sump filtration system, as compared to plugging which is due to the settling of any size debris in downstream components long-term. The evaluations performed for downstream components at Seabrook considered both blockage and plugging as required for a particular component type, although the terminology was used interchangeably in the evaluations. The following summarizes the evaluation of downstream components that was performed at Seabrook, using the blockage and plugging terminology consistent with the GL 2004-02 Requested Information Item.

As part of the resolution for GSI-191, the existing sump screen system was removed and replaced with General Electric (GE) stainless steel plenum strainers. Following the installation, the strainer opening size has been reduced from a 0.097" nominal square opening (0.137 in. nominal diagonal opening) to a new nominal round opening of 1/16 in. diameter (0.0625 in.). The new strainer system is described in the response to NRC Topic 3.j, *Screen Modification Package*.

WCAP-16406-P Section 5.5 provides assumed particle dimensions for recirculation debris ingestion based on sump screen hole dimensions. Rather than the WCAP-16406-P suggested asymmetrical dimensions, the Seabrook downstream components were analyzed for blockage based on a maximum 0.1 in. spherical particle. The actual maximum spherical size particulate debris that can pass through the strainer system and into the ECCS and CBS recirculation flowpaths is documented as particles less than 0.068 in.

All ECCS and CBS downstream components that see active flow during recirculation (including control valves, orifices, flow elements, CBS spray nozzles, and heat exchanger tubes) were analyzed for blockage due to this maximum particulate debris size. All flowpaths that could see recirculation flow per the plant design basis were considered. In accordance with the WCAP-16406-P methodology, the minimum clearance dimension within the component was checked to ensure it is larger than 0.1 in. The results of that analysis are summarized below. Where necessary, low-flow components and piping were analyzed for plugging due to settling, as described below. Finally, static instrument sensing lines, relief valves, and check valves required to close during recirculation were analyzed for potential debris interference as discussed below.

Control Valves

WCAP-16406-P Section 7.3 lists possible failure modes for valve types that can be expected in the recirculation flowpaths. The SER Section 3.2.5 notes that this list is comprehensive and acceptable for general use, but notes that it is not all-inclusive. In accordance with the SER recommendation, all valves in all possible recirculation flowpaths were considered and found to be of standard types as listed in WCAP-16406-P Section 7.3. Every recirculation control valve was compared to the general criteria in WCAP-16406-P Table 8.2-3; any valve requiring further evaluation for plugging per WCAP-16406-P Section 8.2.4 was identified, including all throttled valves (globe, needle, and butterfly) and globe and check valves less than 1.5 in. nominally. The minimum flow clearance through these valves was determined from vendor drawings, and for any throttled valves based on the subcomponent dimensions and lift settings. This minimum flow clearance was compared to the cross-sectional area of a 0.1 in. sphere to ensure that blockage would not occur. The WCAP-16406-P does not require analyzing valves for debris settling. In general, control valves see higher flow velocities than the pipe leading to them, and therefore the valves were not checked for debris settling where the pipe velocity was sufficient (see below).

Root valves and other valves in static instrument sensing lines were analyzed with those instrument lines as discussed below. Relief valves were analyzed for interference as discussed below. Check valves that open but then may require closing during recirculation were also checked for possible interference issues as identified in WCAP-16406-P Table 7.3-1. This could occur where low flow causes debris settling around the valve seat while open, and then the debris prevents proper closure when the check valve should close. In accordance with WCAP-16406-P guidance, a flow velocity of 0.42 ft/s was considered sufficient to prevent debris settling and thereby preclude interference with proper valve closure. The flow velocity for settling was determined from the larger flow area of the nominal pipe size leading to the valve.

No valves were found to be at risk of blockage because all flow clearances were sufficiently large to preclude blocking or the flow velocity in the line precluded the transport of debris large enough to block the valve (sampling lines, only). Because flow velocities are fast enough to preclude debris settling, all control valves were found to be acceptable with respect to plugging and interference during recirculation. Again, relief valves and instrumentation root valves were addressed separately as discussed below.

Relief Valves

Relief valves on the recirculation flow paths were also considered for interference issues. Here, the maximum pressure in the primary line during recirculation operation was conservatively determined based on maximum containment pressure, pump shut-off heads, and no line losses. Where the relief valve set pressure was higher than this pressure, it was determined not to open during recirculation and therefore debris interference was not an issue. If a relief valve could potentially open, then blockage and the effects of debris interference with closure would be considered. One relief valve is subject to opening during recirculation, but this was determined to be acceptable. All other relief valves were found not to be subject to opening during recirculation.

Heat Exchangers

All heat exchangers that see recirculation flow were also considered for blockage and plugging. This included both the major heat exchangers as well as those in the pump seal subsystems that see debris-laden flow. In accordance with WCAP-16406-P Section 8.3.1, the inner diameter of tubes was compared to the maximum assumed particle size. In accordance with the SER Section 3.2.6, the heat exchanger tubes were also checked for plugging due to settling within the tubes, by comparing the minimum average flow velocity in the tubes to the WCAP-16406-P settling velocity (0.42 ft/s). All heat exchangers were found to be acceptable with respect to blockage and plugging.

Orifices, Flow Elements, Spray Nozzles

All orifices, flow elements, and spray nozzles in the ECCS and CBS recirculation flowpaths were checked for blockage. In accordance with WCAP-16406-P Section 8.4, the minimum flow clearance of each was compared to the maximum assumed particle size. All orifices, flow elements, and spray nozzles were found to be acceptable with respect to blockage. The WCAP-16406-P does not suggest analyzing orifices, flow elements, and spray nozzles for debris settling. In general, orifices, flow elements, and spray nozzles see higher flow velocities than the pipe leading to them, and therefore were not checked for debris settling where the pipe velocity was sufficient (see below).

Instrumentation Lines

All instrumentation branch lines on the ECCS and CBS recirculation flow paths were analyzed for blockage and plugging. WCAP-16406-P Section 8.6 generically justifies static flow (water-solid) sensing lines on the basis of minimum expected flow velocities compared to debris settling velocities. However, the Seabrook review of instrument lines was plant specific. First, the actual orientation of each instrument line was determined. Water-solid sensing lines oriented horizontally or above are considered not susceptible to debris settling into the lines. For any instrument lines oriented below horizontal, the actual minimum flow velocity through the header line at the point of the branch was determined. This velocity was compared to the WCAP-16406-P bounding settling velocity of 0.42 ft/s, as opposed to the lower debris-specific settling velocities listed in WCAP-16406-P Table 8.6-1. This approach is consistent with the recommendation of the SER to WCAP-16406-P. All sensing lines at Seabrook are oriented horizontally or above and so were found to be acceptable with respect to plugging due to debris settling. Because the lines are water-solid, they are not susceptible to direct blockage due to large debris flowing into the lines.

Any sampling lines on the ECCS and CBS recirculation flowpaths that are required by plant procedure to be used post-accident were also considered. The sampling lines were analyzed as any other flow path when opened to take a sample: blockage and plugging of the tubing and each component was considered. The orientation of each sampling line was also checked, like an instrument line, to ensure it was not susceptible to settling of debris into the line when water-solid. All sampling lines were found to be acceptable.

The RVLIS installed at Seabrook is a Westinghouse design. Flows in the lower plenum during recirculation would be minimal, so debris and particulates would most likely collect in the lower plenum around the instrument nozzle used for the RVLIS connection. The minimal flows in the lower plenum and the restricted path for flows through the instrument column would significantly limit the flow of particulates reaching the RVLIS connection. RVLIS impulse lines are dead-ended, so particulates would not be drawn into the RVLIS connection and would not collect in sufficient quantity to create a seal against Δ psi produced by system pressure and water level changes. Therefore, debris and particulates collecting in the lower plenum would not affect RVLIS water level measurements.

Piping

The WCAP-16406-P does not require evaluation of piping for potential blockage or plugging. However, in accordance with the SER Section 3.2.6, ECCS and CBS system piping was evaluated for potential plugging due to debris settling. As stated above, control valves in the ECCS and CBS lines were checked to ensure debris settling does not interfere with valve movement. The valves were checked using the flow area of the pipe in which the valves are installed. Therefore, the evaluation for control valves was used to validate that settling will not occur in the system pipes generally. It was verified that the analysis of control valves included valves in all lines in the ECCS and CBS used for recirculation, so that local flow velocities of the various line sizes and flow rates in the Seabrook ECCS and CBS were all considered. As with other settling reviews, the minimum expected system flow rates in each line were used to minimize the flow velocity. The average velocity was determined for each pipe size based on the specific flow rate in that line and compared to the bounding settling velocity of 0.42 ft/s. All valve locations, and therefore all lines, were found acceptable with respect to plugging. Piping was not considered specifically for blockage because flow restrictions in the lines are more limiting with respect to minimum flow clearance.

Reactor Internals and Fuel Blockage

GL 2004-02 Requested Information Item 2(d)(v) includes the fuel assembly inlet debris screen as an example of flow restrictions in the ECCS and CSS flowpaths downstream of the sump screen that must be considered for blockage. Reactor internals and fuel blockage was evaluated utilizing WCAP-16793-NP and is addressed in the response to Topic 3.n, Downstream Effects – Fuel and Vessel.

Pumps

The WCAP-16406-P addresses two concerns with regard to debris blockage or plugging. First, Section 7.2 states that debris in the pumped flow has the potential of blocking the seal injection flow path, or limiting the performance of the seal components due to debris buildup in bellows and springs. A review of the Seabrook ECCS and CBS pump seals in accordance with the WCAP-16406-P methodology determined that the RHR (LHSI) pumps have seal injection arrangements using only recirculated seal cavity fluid. This precludes blockage of the seal injection flow path and the injection of debris laden post-LOCA fluids into the seal cavity chamber so that sump debris will not enter the seal chamber and will not impact the operation of seal internal components. The Safety Injection pump (IHSI), charging pump (HHSI), and CBS pump seals have a seal cooling system relying on the injection of process water. Cyclone separators are not present in these seal cooling systems, which is consistent with WCAP-16406-P recommendations. A plant-specific evaluation of the LHSI, IHSI, HHSI, and CBS pump seal arrangements was performed by Westinghouse. The evaluation concludes that the flow velocities do not suggest a sizable amount of debris will be drawn into the seal injection line. The debris that is introduced into the seal injection path is too small to cause blockage and will not settle in the mechanical seal region. Therefore, because the seal injection will be maintained and the bellows and springs will remain functional, the ECCS and CBS pumps are acceptable with regards to blockage and plugging.

The SER Section 3.2.6 disagreed with a WCAP-16406-P statement that seal failure due to debris ingestion is considered unlikely, because the WCAP-16406-P statement was founded upon only a single test. However, since the Seabrook LHSI pump seals use only recirculated seal cavity fluid in the spring and bellow areas of the seal that were identified as a concern, the SER Section 4.0 limitation expressing concern with this WCAP-16406-P statement is not applicable. Again, plant-specific evaluation of the IHSI, HHSI, and CBS pump seal arrangements found them to be acceptable for recirculation use. Otherwise, the SER endorses the mechanical seal analysis recommended by the WCAP-16406-P with respect to debris interference.

WCAP-16406-P Section 7.2.3 further states that running clearances of 0.010 inch on the diameter could be clogged when exposed to pumpage with 920 PPM and higher debris concentration from failed containment coatings. It states that as a consequence of the clogging, a packing type wear pattern was observed on the rotating surface. This clogging of running clearances creates asymmetrical wear, but was not identified as having a negative impact on pump performance aside from increased wearing (which was considered as discussed below). Also, the WCAP-16406-P states that shaft seizure due to packing debris build-up is unlikely. The SER Section 3.2.5 also endorses this WCAP-16406-P guidance.

No other areas of concern for debris plugging or blockage within ECCS and CBS pumps were identified by either the WCAP-16406-P or the SER. Wear analysis of the pumps due to debris-laden water in close-tolerance running clearances, including packing type debris build-up, was considered as discussed below.

Conclusion (Blockage/Plugging)

As summarized above, analysis of all lines and components in the recirculation flowpaths at Seabrook determined that there is no potential for either debris blockage or long-term plugging, which would threaten adequate core or containment cooling.

Wearing of ECCS and CBS Recirculation Flowpath Components

GL 2004-02 Requested Information Item 2(d)(vi) concerns excessive wear of ECCS and CBS recirculation components due to extended post-accident operation with debris-laden fluids. All ECCS and CBS downstream components that see active flow during recirculation (including pumps, control valves, orifices, flow elements, containment spray nozzles, piping, and heat exchanger tubes) were analyzed for wear due to an analytically determined bounding debris load for the full recirculation mission time. All flowpaths that could see recirculation flow per the plant design basis were considered.

The evaluation of long-term wearing of ECCS and CBS recirculation components was performed for a 30-day period following initiation of recirculation post-LOCA. The 30 days period is consistent with the SE of NEI 04-07, WCAP-16406-P, and the Seabrook UFSAR. All components were analyzed for a full 30 days of operation, unless plant specific procedures and system configurations established a shorter maximum duration of operation. WCAP-16406-P Section 4.2 provides guidance for reducing mission times outside of plant licensing basis for components that are predicted to fail due to recirculation wear. However, consistent with SER Section 3.2.2, only plant-specific component mission time input in accordance with design and licensing basis was utilized for any deviation from a 30 day mission time, and only existing design basis hot-leg recirculation methods were credited. The following summarizes the evaluation of downstream components that was performed at Seabrook.

Debris Concentration and Size Distribution

The Seabrook debris concentration and size distribution for downstream effects wear was calculated based upon the methodology provided by WCAP-16406-P, except as otherwise noted.

The total debris load was determined for a bounding LBLOCA in accordance with NEI 04-07. A minimum sump water volume for recirculation was determined to maximize the debris concentration in containment. All debris was assumed to be in the sump pool and eroded (to the extent it would be after 30 days) at the start of recirculation. Only fiberglass insulation (Nukon) was categorized into fines and debris too large to pass the strainer; this categorization was based on industry experimental data. All other debris was assumed to be entirely fines, capable of passing the strainer unless its final eroded size is larger than 0.1 in. based on a detailed size distribution described below (see above regarding debris size assumed to pass through the strainer). Based on these inputs, the initial debris concentration at the start of recirculation was calculated.

The debris concentration was then depleted over the recirculation mission time in accordance with the methodology presented in WCAP-16406-P Section 5. For the purposes of debris depletion, only latent particulate debris and unqualified coatings were size distributed. The latent debris size distribution was calculated from industry data. The distribution was calculated based on empirical data and for the specific debris types at Seabrook, but the distribution was not based on plant-specific testing. For unqualified coatings, the size/mass distributions of the WCAP-16406-P were used. Qualified coatings were *not* taken to fail entirely to 10 micron spherical particulate, which is consistent with the WCAP-16406-P as amended by the SER Section 3.2.15 since a fibrous thin-bed was not substantiated. While SER Section 3.2.15 states that plant-specific analysis should be performed to size the coating debris, 50 microns was assumed as the coating debris size for qualified coatings based on the upper size limit documented in NEI 04-07 Appendix A .

The particulate debris distribution (in addition to reducing the amount of debris assumed to initially pass the strainer, as discussed above) was utilized to deplete the particulate over time due to settling in the reactor vessel. Consistent with the WCAP-16406-P guidance, the particulate debris size subject to vessel depletion was calculated for each debris type based on force balance methods using a maximum core flow rate (cold leg recirculation for a hot leg break) to minimize debris settling. All particulate debris was assumed to be spherical for determination of settling size. Debris smaller than the calculated size for a given type was taken to remain in solution throughout recirculation. The depletion coefficient for depletable particulate was calculated according to WCAP-16406-P Section 5.8 based on plant specific inputs for conditions to minimize depletion.

Two deviations were taken from the WCAP-16406-P approach with respect to fibrous debris depletion. First, all fiber was assumed to be depletable and no fibrous debris is too small as to remain in solution. Second, in lieu of the 95% fiber capture efficiency for the strainer suggested by WCAP-16406-P, or an empirically determined fiber capture efficiency as stated by the SER Section 3.2.17, the strainer capture efficiency was calculated based on an equation originally found in Draft Rev. 0 of the WCAP-16406-P. This resulted in a conservative strainer capture efficiency of only 49%. However, in all cases, the depletion coefficient used for the fibrous debris was the SER and WCAP-16406-P agreed conservative value of (λ = 0.07/hr or half-life of 10 hours).

For analysis of abrasive wear (pump moving parts), the debris was further categorized based on the size distribution of particulate debris as erosive versus abrasive debris. All fibrous debris was assumed to be large enough to be abrasive. For particulate debris, a modification to the WCAP-16406-P methodology was used to refine the distribution of abrasive versus erosive debris. While the WCAP-16406-P considers 50 microns to be the constant threshold for abrasive debris (which is equal to 2.5X the wear ring gap of the hypothetical pump considered therein), Seabrook used 2.5X the actual wear ring gap at any given time to define the threshold for abrasive-sized particulate. In other words, as the wear ring gap opens, the abrasive debris is reduced. However, the amount of abrasive debris that was reduced was then taken to contribute to erosive wear.

The calculation of erosive wear considered the effect of small particulates. Credit was taken for reduced erosive wear in accordance with the Hutchings Summation methodology presented in WCAP-16406-P Appendix F. The Hutchings Summation was conservatively calculated based upon the particulate distribution discussed above.

The time-dependent debris concentration calculated according to the above methodology was then utilized for the calculation of wear on all ECCS and CBS recirculation components. The calculation of wear for each type of component, including the effect of the wear on component performance, is summarized below.

Pumps

The ECCS and CBS pumps were analyzed for wear in general accordance with the methodology presented in Sections 7.2 and 8.1 of WCAP-16406-P. The depleting abrasive and erosive debris concentrations as discussed above were a primary input of the analysis.

For all pumps, the wear rings were assumed to have a starting gap equal to the midpoint of the wear ring acceptability range prescribed by the pump manufacturer. All wear rates were calculated specifically for each Seabrook pump based on actual pump dimensions, materials, and operating speeds, and the debris concentration at a given time (the generic wear rates determined in the WCAP-16406-P were not applied). The wear analysis considered the combined effect of abrasive wear due to larger debris and debris packing, and erosive wear due to smaller debris (as defined above). The wear rate at each hour was numerically integrated to determine the total material wear following the recirculation mission time.

Pump wear analysis considered the combined effect of abrasive wear due to larger debris, and erosive wear due to smaller debris (as defined above). In accordance with WCAP-16406-P Appendix Q and the SER Section 3.2.23, a penalty was applied to the debris concentration wear rate because the total concentration of abrasive particulates and fibrous debris exceeded 720 PPM. A conservative deviation from the WCAP-16406-P approach was made in that all debris large enough to be abrasive was considered to wear equally, as opposed to the WCAP-16406-P approach of taking coatings as softer. In accordance with the SER Section 3.2.23, the ratio of abrasive to fibrous debris was verified as less than 5 to 1.

The single-stage CBS and LHSI pumps were analyzed for symmetrical wearing of the inboard and outboard wear rings (no "suction multiplier" was applied). Packing-type wear was not applied to the single-stage pumps, in accordance with the WCAP-16406-P. The total material wear after the recirculation mission time was then used to determine the final wear rings gaps for the suction and discharge side. The change in gap was used to evaluate the impact on pump hydraulic performance per the approach of WCAP-16406-P Section 8.1. The discharge head following 30 days of wear was determined to be acceptable for the CBS and LHSI pumps. Per WCAP-16406-P Section 8.1.4, no vibration analysis was performed for single-stage pumps. The mechanical seals were evaluated for debris interference concerns as discussed above.

The multistage IHSI and HHSI pumps were also analyzed for concurrent abrasive and erosive wear. Here, however, packing-type abrasive wear was found to be more limiting than free-flowing abrasive wear. Therefore, the IHSI and HHSI pumps were analyzed according to the Archard wear model presented by WCAP-16406-P Appendix O. For inputs into the Archard wear equation, the pressure drop across the wear rings was calculated for the actual Seabrook pumps based on actual pump head at the expected recirculation flow rate, actual pump (subcomponent) dimensions were used, the eccentricity was assumed maximum, and the wear coefficient was taken as the bounding of the range provided by the WCAP-16406-P. The packing was assumed to occur immediately upon pump recirculation initiation, and to continue until a wear ring gap of 50 mils was attained, at which point the packing at each discharge-side wear ring was assumed to expel, in accordance with the WCAP-16406-P methodology. If the expulsion of the packing occurred prior to the end of the analyzed mission time, the wear of the discharge side wear ring was analyzed for continuing abrasive and erosive wear (free-flow) until the end of the mission time. The suction-side wear rings were taken to wear asymmetrically as a result of the packing-wear on the discharge side, and were analyzed using a suction multiplier of 0.205, per PWR Owners Group document OG-07-510.

The final wear ring gap of the suction and discharge sides after the recirculation mission time was then utilized to perform hydraulic and vibration analyses of the multistage pumps. Based on the pumps' starting discharge head (per IST history) and the acceptable range, the discharge head following 30 days of wear was determined to be acceptable for the IHSI and HHSI pumps. The shaft centering load (Lomakin effect) method in WCAP-16406-P Appendix O was used to evaluate the IHSI and HHSI pumps for vibration failure due to wear. In order to maximize vibration, the centering load was maximized by assuming a minimum friction coefficient, maximum eccentricity, and also maximized in relation to C_d (diametric clearance) and f (friction coefficient). Again, the wear ring pressure drop was calculated based on actual pump head at the expected recirculation flow rate. The resulting shaft stiffness based on the centering load and wear ring gap was calculated using the suction and discharge side wear ring gaps following 30 days of wear.

The stiffness was compared with the stiffness that would result from increasing the wear ring gap to 2X or 2.8X the manufacturer's allowable wear ring gap (symmetric wear acceptability criterion from WCAP-16406-P). The 2.8X criteria was applicable to the Seabrook HHSI pumps because they are 2.5" Pacific Pump Model RLIJ, eleven stage pumps. WCAP-16406-P Section 8.1.5, Appendix H supports the conclusion that this pump model is acceptable for the 2.8X criterion. The Seabrook IHSI pumps were analyzed to the default 2X wear ring gap symmetric wear criterion. The shaft stiffness of the IHSI and HHSI pumps under asymmetric wear was found to be greater than this acceptance criteria, and therefore the IHSI and HHSI pumps were determined to be acceptable with respect to vibration. The mechanical seals were evaluated for debris interference concerns as discussed above.

Non-mechanistic failure of an ECCS or CBS pump seal is considered as a single-failure in the plant design basis and is acceptable. The WCAP-16406-P attempts to justify failure of the seals due to recirculation debris, which is a potential common-mode failure. The LHSI pump seals at Seabrook have been evaluated as not susceptible to failure by debris-laden water because they recirculate only seal cavity fluids, while the IHSI, HHSI, and CBS pump seal injection system using process water has been evaluated as acceptable for long-term recirculation. Therefore the only potential failure that must be considered is an assumed single failure, which again is part of the existing design basis of the plant (bounded by a moderate energy line break in the pump room). There is a potential for debris to cause an increased leakage flow through the disaster bushing following that single-failure. A plant-specific evaluation of the LHSI, IHSI, HHSI, and CBS pump disaster bushings was performed by Westinghouse. The evaluation concludes that if it is assumed that wear and failure of the primary seal could occur, the disaster bushing, would wear a negligible amount in 30 minutes, and that the leakage rate of the pump would be kept to an acceptable limit until the leakage could be isolated and another train of ECCS or CBS could be started.

The WCAP-16406-P criteria were based on performance of each individual component. However, the SER further identifies the need to check the entire ECCS and CBS systems in an integrated approach to ensure that the combination of pump and system component wear would not threaten adequate core cooling, considering increased system flow and decreased pump performance due to wear. An overall system performance assessment determined that these systems remain capable of fulfilling their required safety related functions in the presence of debris-laden fluid following a LBLOCA at the Seabrook Nuclear Power Plant.

Heat Exchangers

In accordance with WCAP-16406-P Section 8.3, the recirculation heat exchangers (both the primary system heat exchangers, and the pump seal heat exchangers) were analyzed for erosive wear. The standard erosive wear formulas in the WCAP-16406-P, adjusted for the actual material hardness and adjusted via the Hutchings Summation described above, were used with the Seabrook heat exchanger dimensions and maximum recirculation flow rates to predict the maximum erosive wear over 30 days of recirculation. All heat exchangers were found to have sufficient wall thickness margin for a maximum possible differential pressure across the heat exchanger tubes.

Valves

The WCAP-16406-P guidance is that manual throttle valves should be analyzed for the effects of erosive wear. It is assumed that a manually throttled valve as defined in WCAP-16406-P is one that requires an operator to locally throttle the valve (at the valve location) as opposed to a remote manual valve that can be adjusted from the control room. It is further assumed that a remote manual valve can be adjusted from the control room to compensate for an increase in flow area due to erosive wear. Therefore, erosion wear analyses were not performed for remote manual valves. All locally throttled ECCS or CBS valves at Seabrook were evaluated for the effects of erosive wear related to valve wall thinning and system flow increase. All locally throttled valves were found to have adequate wall-thickness margin. On initial analysis, one valve location was found to have a potential flow increase greater than the WCAP-16406-P criterion of 3%. All other locally throttled valves were found acceptable with regards to impact on system flow due to erosive wear.

Further evaluation was performed by Westinghouse for the valve location that was initially determined to potentially wear beyond a 3% flow increase. This valve was analyzed using the general methodology of WCAP-16406-P and the wear model in WCAP-16571-P. Differences from the original analysis include the debris concentration was based on a reduced fibrous debris concentration, all unqualified coatings larger than 400 µm and all other debris larger than 100 µm was assumed to deplete, latent particulate and fiber is assumed all to be of characteristic size, and the unqualified coatings distribution was from WCAP-16406-P. This further evaluation determined the wear of this valve location to meet the 3% flow increase criterion.

Orifices, Flow Elements, Spray Nozzles

All orifices, flow elements, and the CBS spray nozzles in the Seabrook recirculation flowpaths were analyzed for the effects of erosive wear upon performance. The standard erosive wear formulas in the WCAP-16406-P, adjusted for the actual material hardness and adjusted via the Hutchings Summation described above, were used with the Seabrook component dimensions and maximum recirculation flow rates to predict the maximum erosive wear over 30 days of recirculation. Other than the shortening of mission time on a case by case basis in accordance with procedural system configurations as previously described, the CBS spray nozzles were analyzed for 14 days of wear during recirculation operation. This is more than twice the maximum expected duration of CBS operation based on the bounding design basis containment LOCA analysis and procedural criteria for CBS termination. The total material wear was used with the WCAP-16406-P formulas to predict the maximum change in flow rate due to the erosive wear of an orifice, flow element or spray nozzle. A conservative deviation was made from the WCAP-16406-P guidance in that a 3% limit for change in flow was applied for all orifices, flow elements, and spray nozzles. Furthermore, all orifices were assumed to be sharp-edged, which creates a higher change in flow rate for a given amount of wear. On initial analysis, two flow restriction locations were found to have a potential flow increase greater than the 3% criterion. All other Seabrook orifices, flow elements, and the CBS spray nozzles were found to be acceptable.

Further evaluation was performed by Westinghouse for the flow restriction locations that were initially determined to potentially wear beyond a 3% flow increase. These flow restrictions were analyzed as described above for the valve location analyzed by Westinghouse. This further evaluation determined the wear of these flow restriction locations to meet the 3% flow increase criterion.

Piping

The SER to WCAP-16406-P requires that licensees perform a piping wear evaluation. The SER Section 3.2.6 does not detail the scope of the assessment, but since it refers to the need for a vibration assessment if areas of high piping wear are identified, it is taken to mean that piping should be checked for wall-thinning (structural) purposes like the heat exchanger tubes. With regard to pipe wall erosion, WCAP-16406-P states "There is no expected impact on ECCS and CSS piping based on downstream sump debris...since the pipe wall thickness is sufficiently larger than expected wear." To validate this assumption, the material wear of the bounding orifice in the HHSI, IHSI, LHSI, and CBS systems was compared to the pipe wall thicknesses used in those systems. This conservative material wear exceeds that applicable to piping because the flow velocities in piping are much less compared to the bounding orifice velocity (the wear rate is proportional to the flow velocity squared), while the material of construction is the same. In each case, the material wear was found to be insignificant compared to the pipe wall thicknesses used in the ECCS subsystems and CBS. Therefore, all recirculation pipes were determined to have sufficient margin, and the erosion was considered so slight as to not require vibration analysis.

Conclusion (Wear)

No other components required erosive wear analysis. As summarized above, analysis of all lines and components in the recirculation flowpaths at Seabrook determined that the components are expected to wear acceptably based on the WCAP-16406-P criteria for 30 days of recirculation.

The WCAP criteria were based on the performance of each individual component. The SER further identifies the need to check the ECCS and CBS systems in an integrated approach to ensure that the combination of pump and system component wear would not threaten adequate core cooling, considering increased system flow and decreased pump efficiency due to wear. Based on an overall system performance assessment, the ECCS and CBS remain capable of fulfilling their required safety related functions in the presence of debris-laden fluid following a LBLOCA at the Seabrook Nuclear Power Plant.

Summary of Design or Operational Changes

Additionally, NRC Content Guide Topic 3.m requests that licensees "Provide a summary of design or operational changes made as a result of downstream evaluations."

The only plant design change made in response to GSI-191 that contributes to the resolution of downstream effects is the upgrade of the sump strainer system. As previously discussed, in response to downstream blockage concerns the new strainer system was designed with nominal strainer opening holes of 1/16 in. diameter (0.0625 in.), reduced from the previous 0.097 in. nominal square opening (diagonal dimension of 0.137 in.). The new strainer system is described in the response to NRC Topic 3.j, *Screen Modification Package*. The actual maximum spherical size particulate debris that can pass through the new strainer system and into the ECCS and CBS recirculation flowpaths is documented as 0.068 in.

The only operational change related to downstream effects is the inspection requirements for the new strainer system. Inspection of the strainer system requires verification of maximum strainer equipment gaps to meet new specifications to maintain debris bypass size limits.

The design and installation acceptance criteria required that, upon completion of installation activities, there would be no holes or gaps greater 0.068 inch in the strainers or 0.375 inch in the debris interceptors. For example, it was required that if a gap between the concrete and strainer plenum steel exceeded the gap acceptance criteria, it was to be filled with an epoxy filler material. The design is such that, after installation is completed, the gap size cannot be increased unless a strainer (or debris interceptor) is damaged by impact or corrosion. (Note that damage due to corrosion is highly unlikely because the strainers and debris interceptors are constructed from stainless steel.) The recirculation sump surveillance procedure has been updated to inspect the strainers and debris interceptors for visible damage or corrosion, and to confirm that there is no debris present on the strainers or debris interceptors.

No other design or operational changes were required in response to ECCS and CBS downstream effects evaluations.

Topic 3.n: Downstream Effects – Fuel and Vessel

FPL Response

FPL is participating in the PWR Owners Group (PWROG) program to evaluate downstream effects related to in-vessel long-term cooling. The results of the PWROG program are documented in WCAP-16793-NP (WCAP-16793-NP, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous and Chemical Debris in Recirculating Fluid," Rev. 0, May, 2007), which was provided to the NRC staff for review on June 4, 2007. The program was performed such that the results apply to the entire fleet of PWRs, regardless of the design (e.g., Westinghouse, CE or B&W).

The PWROG program demonstrated that the effects of fibrous debris, particulate debris and chemical precipitation would not prevent adequate long-term core cooling flow from being established. In the cases that were evaluated, the fuel clad temperature remained below 800 °F in the recirculation mode. This is well below the acceptance criterion of 2200 °F in 10 CFR 50.46, *Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors.* The specific conclusions reached by the PWROG are noted below.

- Adequate flow to remove decay heat will continue to reach the core even with debris from the sump reaching the RCS and core. Test data has demonstrated that any debris that bypasses the screen is not likely to build up an impenetrable blockage at the core inlet. Any debris that collects at the core inlet will provide some resistance to flow. In the extreme case where large blockage does occur, numerical analyses have demonstrated that core decay heat removal will continue. Per WCAP 16793-NP, Revision 0, no plant specific evaluation is recommended. This conclusion thus applies to Seabrook Unit 1.

- Decay heat will continue to be removed even with debris collection at the fuel assembly spacer grids. Test data has demonstrated that any debris that bypasses the screen is small and consequently is not likely to collect at the grid locations. Further, any blockage that may form will be limited in length and not be impenetrable to flow. In the extreme case that a large blockage does occur, numerical and first principle analyses have demonstrated that core decay heat removal will continue. Per WCAP 16793-NP, Revision 0, no plant specific evaluation is recommended. This conclusion thus applies to Seabrook Unit 1.

- Should fibrous debris, enter the core region, it will not tightly adhere to the surface of fuel cladding. Thus, fibrous debris will not form a "blanket" on clad surfaces to restrict heat transfer and cause an increase in clad temperature. Therefore, adherence of fibrous debris to the cladding is not plausible and will not adversely affect core cooling. Per WCAP 16793-NP, Revision 0, no plant specific evaluation is recommended. This conclusion thus applies to Seabrook Unit 1.

- Using an extension of the chemical effects method developed in WCAP-16530-NP to predict chemical deposition of fuel cladding, two sample calculations using large debris loadings of fiberglass and calcium silicate, respectively, were performed. The cases demonstrated that decay heat would be removed and acceptable fuel clad temperatures would be maintained.

WCAP-16530-NP, Revision 0, evaluated the potential for chemical precipitation to form on the cladding surface as summarized in the preceding bullet, which is demonstrated in WCAP-16793, Revision 0, to produce acceptable fuel clad temperature results for two sample cases. As recommended in the WCAP-16793-NP, Revision 0, Seabrook has performed a plant-specific calculation using plant-specific parameters and the recommended WCAP methodology to confirm that chemical plate-out on the fuel does not result in the prediction of fuel cladding temperatures approaching the 800 °F value.

The calculation performed for Seabrook determined the maximum temperature for two cases; (a) minimum sump volume and (b) maximum sump volume. In both cases the calculation concluded that the maximum fuel cladding temperature is 408.7 °F.

Topic 3.o: Chemical Effects

FPL Response

Continuum Dynamics Incorporated (CDI) performed full-scale sector plant-specific chemical effects testing for Seabrook under contract from General Electric. The testing protocol and test results are described in the response to NRC Topic 3.f: *Head Loss and Vortexing*. Information is provided below to respond to the NRC Chemical Effect RAIs and the "GL Supplement Content" items in Enclosure 3 to the March 28 letter from the NRC to NEI, "Revised Guidance For Review of Final Licensee Responses to Generic Letter 2004-02,'Potential impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors."

[RAI 2] [RAI 3] [RAI 4] The quantities of materials in containment that were used to develop the Seabrook-specific tests are listed below. These quantities include aluminum scaffolding. Because the Seabrook-specific full-scale sector integrated chemical effects tests have been successfully completed, comparisons to ICET are no longer relevant to demonstrating compliance with the regulatory guidance of GL 2004-02.

Table 3.o-1: Materials In Containment

MATERIAL	QUANTITY	DISCUSSION
Aluminum Submerged Non-Submerged Total	 175 ft^2 773 ft^2 948 ft^2	The total aluminum surface area in containment is 848 ft^2, and an additional 100 ft^2 is added for contingency. These values were input into the applicable cells of the WCAP-16530-NP algorithm.
Zinc Galvanized Non-Top Coated	 355,000 ft^2 8,086 ft^2	In accordance with WCAP-16530-NP, Sections 6.1 and 6.2.2, zinc is not included in the chemical precipitate model.
Copper	20,000 ft^2	In accordance with WCAP-16530-NP, Sections 6.1 and 5.1.2, copper is not included in the chemical precipitate model.
Uncoated Carbon Steel	N/A	In accordance with WCAP-16530-NP, Sections 6.1 and 6.2.3, iron is not included in the chemical precipitate model, and, therefore was not estimated.
Uncoated Concrete	1225 ft^2	A point of note is that this data point is not significant in the WCAP-16530-NP algorithm as values ranging from zero to over 1.0E+06 yielded no change in the resulting calculated precipitate values.

[RAI 5] The post-LOCA containment sump and spray water pH quickly levels off at 9.4, assuming a boron concentration of 4000 mg/l and the full injection of the ~20% NaOH in the Spray Additive Tank. Once mixed, the pH of the sump and spray are considered to be the same for the duration do the event. The small difference in the mixing time frame has no impact on the WCAP algorithm or the results.

[RAI 6] Because the Seabrook-specific full-scale sector integrated chemical effects tests have been successfully completed, comparisons to ICET are no longer relevant to demonstrating compliance with the regulatory guidance of GL 2004-02.

[RAI 7] Recirculation is not initiated until at least 26 minutes after the LBLOCA. The minimum pool volume is 49,408 ft^3 (at 160 °F) and the maximum pool volume is 55,355 ft^3 (at 260 °F). The assumptions used to calculate the minimum pool volume are provided in the response to NRC Topic 3.g, *Net Positive Suction Head Available (NPSH)*. Several values from this range were used in the WCAP-16530-NP spreadsheet. As input water volume increased, calculated aluminum oxyhydroxides and silicates increased. At 24 hours after the LOCA the pool temperature is approximately 160 °F.

[RAI 8] Seabrook-specific full-scale sector integrated tests were performed to determine the total head loss including chemical effects. The tests and results are discussed in the response to NRC Topic 3. f: *Head Loss and Vortexing*.

[RAI 9] Because; (a) the completed Seabrook-specific integrated chemical effects testing confirmed that there is adequate NPSH margin, and (b) the completed analyses confirmed that long-term cooling can be maintained, it is not necessary to remove materials from the containment building or change from the existing buffering chemicals to comply with The regulatory requirements listed in the "Applicable Regulatory Requirements" section of GL 2004-02. Therefore, Seabrook does not currently plan to make such changes for the purposes of meeting the requirements of GL 2004-02.

[RAI 10] The amount of precipitates generated at the plant is determined by methodology developed by Westinghouse, referred to as WCAP-16530-NP, which is based on bench-top experiments. The WCAP is an extensive and elaborate method, but basically the precipitate amounts will depend on the time and history profile of the sump temperature and pH, spray duration, and submerged and unsubmerged material history. The quantity of precipitate calculated for Seabrook used Seabrook specific input in the WCAP-16530-NP spreadsheet methodology.

[RAI 11] Continuum Dynamics Incorporated (CDI) performed full-scale sector plant-specific chemical effects testing for Seabrook. The testing protocol and test results are described in the response to NRC Topic 3.f: *Head Loss and Vortexing*. Tests were run with essentially neutral water at 65 °F to 85 °F. The use of neutral water at 65 °F to 85 °F is acceptable because the entire quantities of debris were added to the test water, and the test chemistry was such that it did not influence the form or quantity of fibrous debris, particulate debris or chemical precipitant surrogate. Therefore, the test is representative of the containment pool environment with the maximum calculated chemical and non-chemical debris.

[RAI 12] The maximum projected head losses are described in the response to NRC Topic 3.f: *Head Loss and Vortexing*.

[RAI 13] As discussed above, chemical effects on strainer head loss were evaluated by performing Seabrook-specific full-scale sector integrated head loss tests. These tests utilized the maximum calculated quantity of chemical precipitate as determined by the methodology of WCA16530-NP, which assumes that all dissolved aluminum will form precipitates upon cooling.

Chemical effects on fuel and vessel were evaluated using the methodologies of WCAP-16793-NP and WCAP-16530-NP. These evaluations, and the results thereof, are discussed in the response to NRC Item 3.n, *Downstream Effects – Fuel and Vessel.*

3. (1) .d.i: Sufficient Clean Strainer Area
The Seabrook strainer design does not credit bare strainer area or use a simplified chemical effects analysis.

3. (2) .d.i: Debris Bed Formation
The basis for determining the break that produces the maximum head loss is described in the response to NRC Topic 3.a: *Break Selection*. As described in the response, only one type of insulation, Nukon, will be affected by a bounding break at Seabrook. The most detrimental break is that which produces the most debris because the nature of the materials introduced into the pool by the break is not affected by the break location; only the quantity of materials is affected.

3. (3) .d.i: Plant-Specific Materials and Buffers
The Seabrook chemical product formation analysis assumed continuous containment spray for 30 days. The remaining information was requested in RAIs 2, 3, 5 and 7, and has been provided above in the responses to these RAIs.

3. (4) .c.i: Approach to Determine Chemical Source Term (Decision Point)
Continuum Dynamics Incorporated (CDI) performed the full scale sector plant-specific chemical effects testing for Seabrook under contract from General Electric. The chemical source term was calculated, prepared and tested in accordance with the guidance of WCAP-16530-NP.

3. (6).d.i: AECL Model
Not applicable. Seabrook did not use the AECL model.

3. (7) .d.i: WCAP Base Model
The Seabrook analysis used the WCAP-16530 spreadsheet with inputs intended to maximize the quantity of chemical precipitate formation. The Seabrook analysis did not depart from the WCAP base model spreadsheet.

3. (7) .d.ii: WCAP Base Model
The Seabrook-specific precipitates are listed below.

Table 3.o-2: Precipitate Quantities

	$NaAlSi_3O_8$ (kg)	AlOOH (kg)	Total (Kg)
212 °F (t ~23 minutes)	59.8	0.0	59.8
30 days	303.7	28.5	332.2

3. (9) .d.i: Solubility of Phosphates, Silicates and Al Alloys
The Seabrook chemical effects analyses did not utilize any of the refinements described in WCAP-16785-NP, "Evaluations of Additional Inputs to the WCAP-16530-NP Chemical Model."

3. (9) .d.ii: Solubility of Phosphates, Silicates and Al Alloys
The Seabrook chemical effects analyses did not credit aluminum passivation.

3. (9) .d.iii: Solubility of Phosphates, Silicates and Al Alloys
The Seabrook chemical effects analyses did not credit solubility. It is assumed that all dissolved aluminum will form precipitates upon cooling.

3. (9) .d.iv: Solubility of Phosphates, Silicates and Al Alloys
This information is provided in the response to 3.(7).d.ii above.

3. (11) .d.i: Chemical Injection into the Loop
Chemical effects debris was simulated with aluminum oxyhydroxide. The aluminum oxyhydroxide was fabricated and tested in accordance with the WCAP-16530-NP Procedures. The chemical debris was mixed for a minimum of 60 minutes prior to use. To determine if the debris was suitable for use in testing, two samples were taken. The first sample of the aluminum oxyhydroxide was tested by diluting the sample to 9.7 g/l and allowing the precipitate to settle for 60 minutes. If the turbid portion was more than 90% of the total height in a graduated cylinder, the simulated debris was suitable for use in testing. The second sample was tested by diluting the sample to 2.2 g/l and allowing the precipitate to settle for 60 minutes. For the simulated debris to be used in testing, the turbid portion could not be less than 40% of the total height in a graduated cylinder.

3. (11) .d.ii: Chemical Injection into the Loop
Not Applicable. A prepared precipitate was injected. Raw chemicals were not used in the Seabrook integrated tests.

3. (11) .d.iii: Chemical Injection into the Loop
Testing was performed at the following precipitate levels, 17%, 26%, 30%, 40%, 60%, 80%, and 100%. The head loss at the 100% precipitate level is the head loss of record.

3. (12) .d.i: Pre-mix in Tank
Chemical debris was prepared in accordance with the WCAP 16530 procedures, measured volumetrically, and added as a suspension.

3. (14) .d.i: Integrated Head Loss Test With Near-Field Settlement Credit
Not Applicable. Seabrook did not take credit for Near-Field Settlement.

3. (14) .d.ii: Integrated Head Loss Test With Near-Field Settlement Credit
Not Applicable. Seabrook did not take credit for Near-Field Settlement.

3. (15) .d.i; Head Loss Testing Without Near Field Settlement
The test arrangement for Seabrook was designed to minimize settling. The mixing tank was used to add debris and maintain debris in suspension. The flow returned through the bottom of the tank at the end furthest from the test tank. The return pipe outlet was covered by a plate to direct the flow along the bottom of the mixing tank. Additional agitation was provided by at least two motor driven mixers. The turbulence in the mixing tank ensured that debris would remain in suspension in the tank. The distance from the mixing tank to the top of the full-scale test sector is negligible compared to length of the test sector (5 1/8 inch compared to a test sector length of 97 3/4 inch), and all flow was through the test sector. As a result any settling between the mixing tank and test sector is expected to be negligible.

3. (15) .d.ii: Head Loss Testing Without Near Field Settlement
This information is provided in the response to item 3. (11) .d.i.

3. (16) .d.i: Test Termination Criteria
The termination criteria are that the head loss increase is less than 1% or 0.1 inch water gauge within a 30 minute time period.

3. (17) .d.i: Data Analysis
The pressure drop curve as a function of time for the testing of record is provided in Figure 3.o-1. The combined debris/chemical effects strainer plate loss has a factor of 1/0.95 (~5% increase) to account for the very small possibility that the head loss could increase beyond the termination criteria of 1% change per 30 minute interval.

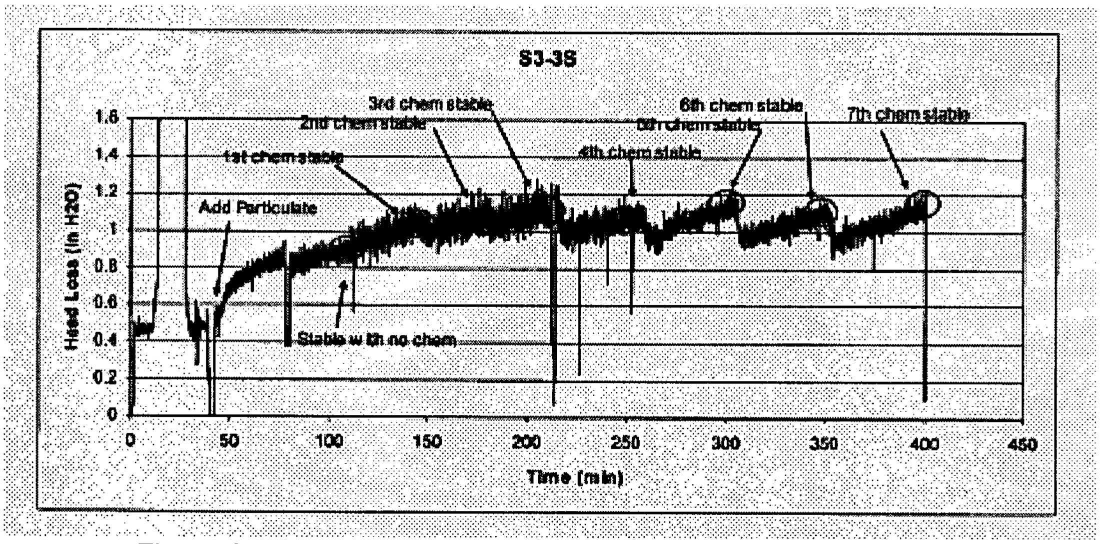


Figure 3.o-1: Headloss as a Function of Time for the Test of Record

3. (17) .d.ii: Data Analysis
Not applicable. Seabrook data analyses did not use extrapolation.

3. (18).d.i: Integral Generation (Alion)

Not applicable. Seabrook tests were not conducted by Alion.

3. (21) .d.i: 30-day Integrated Head Loss Test
Not applicable. Seabrook did not conduct a 30 day test.

3. (21) .d.ii: 30 Day Integrated Head Loss Test
Not applicable. Seabrook did not conduct a 30 day test.

3. (22) .d.i: Data Analysis Bump Up Factor
Not applicable. The Seabrook methodology does not use a bump-up factor in the strainer headloss determination.

Topic 3.p: Licensing Basis

FPL Response

FPL Energy has not requested any license amendments as a result of the implementation of the GL 2004-02/GSI-191 modifications. The UFSAR will be updated as necessary, consistent with the requirements of 10 CFR 50.71(e), to reflect the modifications and other changes made to resolve GL 2004/GSI-191.

Enclosure 1

(Seabrook Supplemental Response)

NRC Safety Evaluation report

Limitations and Conditions

For

WCAP-16530-NP Revision 0

L&C No.	NRC Limitations & Conditions: WCAP-16530-NP Revision 0	Seabrook Response
1	A peer review of NRC-sponsored chemical effects testing was performed and a number of technical issues related to GSI-191 chemical effects were raised by the independent peer review panel members (NUREG-1861). The peer review panel and the NRC staff developed a PIRT of technical issues identified by the peer review panel. The NRC staff is working to resolve the technical issues identified in the PIRT. Part of the resolution process includes NRC-sponsored analyses being performed by PNNL. Although the NRC staff has not developed any information related to the PIRT issues resolution that would alter the conclusions of this evaluation, some issues raised by the peer review panel were not completely resolved at the time this evaluation was written. An example of such an issue is the potential influences of organic materials on chemical effects. Therefore, it is possible that additional analysis or other results obtained during the resolution of the remaining peer review panel issues could affect the conclusions in this evaluation. In that event, the NRC staff may modify the SE or take other actions as necessary.	Not Applicable--This is not a limit or condition. If the NRC staff modifies the SE or takes other actions, Seabrook will respond to any future limitations and conditions as requested
2	This evaluation does not address TR WCAP-16785-NP, "Evaluation of Additional Inputs to the WCAP-16530-NP Chemical Model." The NRC staff will provide comments on WCAP-16785-NP separate from this evaluation. In addition, a separate SE will address a related TR, WCAP-16793-NP, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous, and Chemical Debris in the Recirculating Fluid." Chemical effects in the reactor vessel are not addressed in WCAP-16530-NP or in this SE. Therefore, the approval of this TR does not extend to chemical effects in the reactor vessels.	Not Applicable--This is not a limit or condition. If the NRC staff modifies the SE or takes other actions, Seabrook will respond to any future limitations and conditions as requested. Seabrook used the Pressurized Water Reactor Owners Group (PWROG) methodology, which is in accordance with WCAP-16793-NP, Revision 0, to evaluate chemical effects in the reactor vessel
3	If a licensee performs strainer head loss tests with surrogate precipitate and applies a time-based pump NPSH margin acceptance criteria (i.e., timed precipitate additions based on topical report model predictions), they must use an aluminum release rate that does not under-predict the initial 15 day aluminum concentrations in ICET 1, although aluminum passivation can be considered during the latter parts of the ECCS mission time in this case.	Not applicable. Seabrook did not use a time based pump NPSH margin acceptance criteria or credit aluminum passivation.

L&C No.	NRC Limitations & Conditions: WCAP-16530-NP Revision 0	Seabrook Response
4	For head loss tests in which the objective is to keep chemical precipitate suspended (e.g., by tank agitation): Sodium aluminum silicate and aluminum oxyhydroxide precipitate settling shall be measured within 24 hours of the time the surrogate will be used and the 1-hour settled volume shall be 6 ml or greater and within 1.5 ml of the freshly prepared surrogate. Calcium phosphate precipitate settling shall be measured within 24 hours of the time the surrogate will be used and the 1 hour settled volume shall be 5 ml or greater and within 1.5 ml of the freshly prepared surrogate. Testing shall be conducted such that the surrogate precipitate is introduced in a way to ensure transportation of all material to the test screen.	Chemical effects debris was simulated with aluminum oxyhyroxdide. The aluminum oxyhydroxide was fabricated and tested based on WCAP-16530-NP. The chemical debris was mixed for a minimum of 60 minutes prior to use. To determine if the debris was suitable for use in testing, two samples were taken. The first sample of the aluminum oxyhydroxide was tested by diluting the sample to 9.7 g/l and allowing the precipitate to settle for 60 minutes. If the turbid portion was more than 90% of the total height in a graduated cylinder, the simulated debris was suitable for use in testing. The second sample was tested by diluting the sample to 2.2 g/l and allowing the precipitate to settle for 60 minutes. For the simulated debris to be used in testing, the turbid portion could not be less than 40% of the total height in a graduated cylinder.
5	For head loss testing in which the objective is to settle chemical precipitate and other debris: Aluminum containing surrogate precipitate that settles equal to or less than the 2.2 g/l concentration line shown in Figure 7.6-1 of WCAP-16530-NP (i.e., 1-or 2- hour settlement data on or above the line) is acceptable. The settling rate shall be measured within 24 hours of the time the surrogate precipitate will be used.	Seabrook did not perform strainer head loss tests in which the objective is to settle chemical precipitate and other debris.
6	For strainer head loss testing that uses TR WCAP-16530-NP sodium aluminum silicate and is performed in a de-ionized water environment, the total amount of sodium aluminum silicate added to the test shall account for the solubility of sodium aluminum silicate in this environment.	Seabrook did not utilize sodium aluminum silicate.

Enclosure 2

(Seabrook Supplemental Response)

NRC Safety Evaluation report

Limitations and Conditions

For

WCAP-16793-NP Revision 0

L&C No.	NRC Limitations & Conditions: WCAP 16793-NP Revision 0	Seabrook response
1.	WCAP-16793-NP states that licensees shall either demonstrate that previously performed bypass testing is applicable to their plant-specific conditions, or perform their own plant-specific testing. The staff agrees with this stated position.	The Seabrook plant- specific fiber bypass testing was performed by Continuum Dynamics Corporation under contract to General Electric. Three fiber-only bypass tests were performed using a scaled sector test article which contained the same perforated plate hole size, wire cloth size and vertical stacked disk orientation as the plant strainer.
2.	There are very large margins between the amount of core blockage that could occur based on the fuel designs and the debris source term discussed in WCAP-16793-NP and the blockage that would be required to degrade the coolant flow to the point that the decay heat could not be adequately removed. Plant-specific evaluations referencing WCAP-16793-NP should verify the applicability of the WCAP-16793-NP blockage conclusions to licensees' plants and fuel designs.	A plant specific analysis using the Westinghouse LOCA deposition Model in WCAP 16793-NP was performed for Seabrook Unit 1. The results of the calculation yielded a maximum fuel cladding temperature, and thickest calculated scale, well below the threshold criteria. .
3.	Should a licensee choose to take credit for alternate flow paths such as core baffle plate holes, it shall demonstrate that the flow paths would be effective and that the flow holes will not be become blocked with debris during a loss-of-coolant accident (LOCA) and that the credited flow path would be effective.	No alternative flow paths were used for Seabrook. The flow paths are as described in WCAP 16793-NP, Section 5.4.2, Transport of Coolant, Dissolved Species and Suspended Solids within the ECCS, Page 5-4 and Section 5.4.3, Modeling of the Core, Page 5-5. .
4.	Existing plant analyses showing adequate dilution of boric acid during the long-term cooling period have not considered core inlet blockage. Licensees shall show that possible core blockage from debris will not invalidate the existing post-LOCA boric acid dilution analysis for the plant.	The PWR Owners Group has a project to develop the approach for boric acid precipitation analyses and evaluations, Project Number ACS-0264R1, Post LOCA Boric Acid Precipitation Analysis Methodology Program..
5.	The staff expects the Pressurized Water Reactor Owners Group (PWROG) to revise WCAP-16793-NP to address the staff's requests for additional information and the applicant's responses. A discussion of the potential for fuel rod swelling and burst to lead to core flow blockage shall be included in this revision.	This L&C refers to information to be included in a revision to WCAP 16793-NP. FPL will continue to follow developments out of the PWROG and evaluate new information as it becomes available. .
6.	WCAP-16793 shall be revised to indicate that the licensing basis for Westinghouse two-loop PWRs is for the recirculation flow to be provided through the upper plenum injection (UPI) ports with the cold-leg flow secured.	This L&C is not applicable. Seabrook is a Westinghouse four-loop plant. .
7.	Individual UPI plants will need to analyze boric acid dilution/concentration in the presence of injected debris for a cold-leg break LOCA.	This L&C is not applicable. Seabrook is a Westinghouse four-loop plant.
8.	WCAP-16793 states that the assumed cladding oxide thickness for input to LOCADM will be the peak local oxidation allowed by 10 CFR 50.46, or 17 percent of the cladding wall thickness. The WCAP states that a lower oxidation thickness can be used on a plant-specific basis if that value is justified. The staff does not agree with the flexibility in this approach. Licensees shall assume 17 percent oxidation in the LOCADM analysis.	The Seabrook LOCADM calculation used the 17% cladding oxide thickness. .

L&C No.	NRC Limitations & Conditions: WCAP 16793-NP Revision 0	Seabrook response
9.	The staff accepts a cladding temperature limit of 800°F as the long-term cooling acceptance basis for GSI-191 considerations. Should a licensee calculate a temperature that exceeds this value, cladding strength data must be provided for oxidized or pre-hydrided cladding material that exceeds this temperature.	The Seabrook LOCADM calculation used 800°F as the cladding temperature limit. .
10.	In the response to NRC staff requests for additional information, the PWR Owners Group indicated that if plant-specific refinements are made to the WCAP-16530- NP base model to reduce conservatisms, the LOCADM user shall demonstrate that the results still adequately bound chemical product generation. If a licensee uses plant-specific refinements to the WCAP-16530-NP base model that reduce the chemical source term considered in the downstream analysis, the licensee shall provide a technical justification that demonstrates that the refined chemical source term adequately bounds chemical product generation. This will provide the basis that the reactor vessel deposition calculations are also bounding.	The Seabrook calculation did not use plant-specific refinements to reduce conservatisms in the WCAP-16530-NP base model. .
11.	WCAP-16793-NP states that the most insulating material that could deposit from post-LOCA coolant impurities would be sodium aluminum silicate. WCAP-16793 recommends that a thermal conductivity of 0.11 BTU/hr-ft- °F be used for the sodium aluminum silicate scale and for bounding calculations when there is uncertainty in the type of scale that may form. If plant-specific calculations use a less conservative thermal conductivity value for scale (i.e., greater than 0.11 BTU/hr-ft-°F), the licensee shall provide a technical justification for the plant-specific thermal conductivity. This justification shall demonstrate why it is not possible to form sodium aluminum silicate or other scales with conductivities below the selected value.	The Seabrook LOCADM calculation used the deposit thermal conductivity value of 0.11 BTU/hr-ft-°F. The Westinghouse LOCADM model listed a default value of 0.2 W/m-K, which is the metric equivalent of 0.11 BTU/hr-ft-°F. .
12.	WCAP-16793-NP indicates that initial oxide thickness and initial crud thickness could either be plant-specific estimates based on fuel examinations that are performed or default values in the LOCADM model. Consistent with Conditions and Limitations item number 8, the default value for oxide used for input to LOCADM will be the peak local oxidation allowed by 10 CFR 50.46, or 17 percent of the cladding wall thickness. The default value for crud thickness used for input to LOCADM is 127 microns, the thickest crud that has been measured at a modern PWR. Licensees using plant-specific values instead of the WCAP-16793-NP default values for oxide thickness and crud thickness shall justify the plant-specific values.	The Seabrook LOCADM calculation used 17 percent of the cladding wall thickness for peak local oxidation allowed by 10 CFR 50.46. (See Conditions and Limitations item number 8.) The default value for the crud thickness used for input to the LOCADM calculation was 140 microns. .

L&C No.	NRC Limitations & Conditions: WCAP 16793-NP Revision 0	Seabrook response
13.	As described in the Conditions and Limitations for WCAP-16530-NP (ADAMS ML073520891), the aluminum release rate equation used in WCAP-16530-NP provides a reasonable fit to the total aluminum release for the 30-day ICET tests but under-predicts the aluminum concentrations during the initial active corrosion portion of the test. To provide more appropriate levels of aluminum for the LOCADM analysis in the initial days following a LOCA, licensees shall apply a factor of two to the aluminum release as determined by the WCAP-16530-NP spreadsheet, although the total aluminum considered does not need to exceed the total predicted by the WCAP-16530-NP spreadsheet for 30 days. Alternately, licensees may choose to use a different method for determining the aluminum release, but in all cases licensees shall not use a method that under-predicts the aluminum concentrations measured during the initial 15 days of ICET 1.	The Seabrook calculation applied a factor of two to the aluminum release rate while maintaining the total aluminum release to that of the 30 day mission time. .

Enclosure 3

(Seabrook Supplemental Response)

NRC Safety Evaluation report

Limitations and Conditions

For

WCAP-16406-P Revision 1

L&C No.	NRC Limitations & Conditions: WCAP 16406-P Revision 1	Seabrook Response to L&C
1.	Where a TR WCAP-16406-P, Revision 1, section or appendix refers to examples, tests, or general technical data, a licensee should compare and verify that the information is applicable to its analysis.	General WCAP-16406-P examples and technical data were not used for site specific input. The wear equations developed in the WCAP-16406-P based on tests and general technical data were developed and benchmarked on equipment and with debris similar to that found at Seabrook. The wear equations were adjusted for the specific materials and debris concentration at Seabrook.
2.	A discussion of EOPs, AOPs, NOPs or other plant-reviewed alternate system line-ups should be included in the overall system and component evaluations as noted in the NRC staff's SE of NEI 04-07, Section 7.3 (Reference 13).	The downstream effects analysis for Seabrook considered all procedural recirculation system line-ups that are used by the plant. Alternate line-ups are not utilized at Seabrook as the primary line-ups are all redundant. The system evaluation discusses the procedures and system line-ups.
3.	A licensee using TR WCAP-16406-P, Revision 1, will need to determine its own specific sump debris mixture and sump screen size in order to initiate the evaluation.	The downstream effects analysis uses a bounding site-specific sump debris mixture and the actual sump strainer hole size. Since site specific debris bypass test data were not available, the WCAP-16406-P methodology of strainer efficiency and retention size were utilized. The assumed maximum particulate size capable of passing the strainer was altered from the suggested WCAP-16406-P approach. Fiber penetration size was not available and therefore not considered within the calculation; fibrous debris was modeled as completely depletable based on strainer capture efficiency, only. Debris size distribution was determined based on experimental data (not site specific) and the Seabrook specific debris types were used. Further evaluation was performed for valves and flow restrictions that were initially determined to potentially wear beyond a 3% flow increase. This evaluation was performed using the general methodology of WCAP-16406-P and the wear model in WCAP-16571-P. The debris concentration was based on a reduced fibrous debris concentration, latent particulate and fiber is assumed all to be of characteristic size, and the unqualified coatings distribution was from WCAP-16406-P.
4.	TR WCAP-16406-P, Revision 1, Section 4.2, provides a general discussion of system and component mission times. It does not define specific times, but indicates that the defined term of operation is plant-specific. As stated in the NRC staff's SE of NEI 04-07, Section 7.3 (Reference 13), each licensee should define and provide adequate basis for the mission time(s) used in its downstream evaluation.	Recirculation operation is analyzed for 30 days post-LOCA. The mission time of all components is 30 days unless the plant's recirculation procedures limit the time that specific components are used. Also, the CBS spray nozzles were analyzed for 14 days recirculation based on the bounding design basis containment LOCA analysis and procedural criteria for CBS termination. The 30 day recirculation duration is based on the SE of NEI 04-07, and was reviewed and found to be consistent (does not conflict) with the Seabrook design and licensing basis.
5.	TR WCAP-16406-P, Revision 1, Section 5.8, assumes that the coolant which is not spilled flows into the reactor system and reaches the reactor vessel downcomer. This would be true for most PWR designs except for plants with UPI. Therefore, the methodology of Section 5.8 may not be applicable to plants with UPI and its use should be justified on a plant-specific basis.	Seabrook Is not a UPI plant.

L&C No.	NRC Limitations & Conditions: WCAP 16406-P Revision 1	Seabrook Response to L&C
6.	TR WCAP-16406-P, Revision 1, Section 5.8, provides equations which a licensee might use to determine particulate concentration in the coolant as a function of time. Assumptions as to the initial particulate debris concentration are plant-specific and should be determined by the licensee. In addition, model assumptions for ECCS flow rate, the fraction of coolant spilled from the break and the partition of large heavy particles which will settle in the lower plenum and smaller lighter particles which will not settle should be determined and justified by the licensee.	The initial particulate debris concentration was determined for Seabrook based on plant-specific limiting debris loads and sump water volumes. Debris depletion in the calculations is based on plant specific flows, debris types and debris concentrations. The size of debris subject to settling in the lower plenum was determined on a plant-specific basis; the ECCS flows and spillage assumed are the most conservative for this purpose. Further evaluation was performed by Westinghouse for valves and flow restrictions that were initially determined to potentially wear beyond a 3% flow increase. This evaluation assumed that all unqualified coatings larger than 400 μm and all other debris larger than 100 μm were depletable. Also, latent particulate and fiber was assumed all to be of characteristic size, and the unqualified coatings distribution was from WCAP-16406-P.
7.	TR WCAP-16406-P, Revision 1, Sections 5.8 and 5.9, assumes that debris settling is governed by force balance methods of TR Section 9.2.2 or Stokes Law. The effect of debris and dissolved materials on long-term cooling is being evaluated under TR WCAP-16793-NP (Reference 12). If the results of TR WCAP-16793-NP show that debris settling is not governed by force balance methods of TR Section 9.2.2 or Stokes Law, then the core settling term determined from TR WCAP-16793-NP should be used.	The site specific debris settling was determined in analyses which utilized force balance methods. The methodology uses empirical friction factors based on the debris shape. This methodology is benchmarked against the NRC-sponsored testing of paint chip settling reported in NUREG/CR-6916.
8.	TR WCAP-16406-P, Revision 1, Section 7.2, assumes a mission time of 720 hours for pump operation. Licensees should confirm that 720 hours bounds their mission time or provide a basis for the use of a shorter period of required operation.	Analysis was performed for a mission time of thirty days following initiation of LBLOCA event. No reduction in mission time is credited in this analysis. The use of a full thirty day mission time is consistent with NEI 04-07 and its NRC SER, and the UFSAR. Additionally, use of a 30 day mission time is consistent with the time periods anticipated in NUREG 0800, Section 9.2.5, Ultimate Heat Sink. Reasonable and prudent management and operator action is credited for any actions required beyond thirty days to ensure continued safe operation of needed ECCS and CBS pumps. The mission time of individual components was a full 30 days except where the plant's recirculation procedures limit the time that specific components are used.
9.	TR WCAP-16406-P, Revision 1, Section 7.2, addresses wear rate evaluation methods for pumps. Two types of wear are discussed: 1) free-flowing abrasive wear and 2) packing-type abrasive wear. Wear within close-tolerance, high-speed components is a complex analysis. The actual abrasive wear phenomena will likely not be either a classic free-flowing or packing wear case, but a combination of the two. Licensees should consider both in their evaluation of their components.	The maximum of either free-flow or packing type abrasive wear is considered until a wear ring clearance of 50 mils diametral is reached. Beyond that time, the packing is assumed expelled and free-flow wear (abrasive and erosive) is modeled.

L&C No.	NRC Limitations & Conditions: WCAP 16406-P Revision 1	Seabrook Response to L&C
10.	TR WCAP-16406-P, Revision 1, Section 7.2.1.1, addresses debris depletion coefficients. Depletion coefficients are plant-specific values determined from plant-specific calculations, analysis, or bypass testing. Licensees should consider both hot-leg and cold-leg break scenarios to determine the worst case conditions for use in their plant specific determination of debris depletion coefficient.	Debris depletion coefficients in the calculations are based on plant specific flows, debris types and debris concentrations and the strainer design. The ECCS flows and spillage assumed are the most conservative for this purpose of either cold or hot-leg break scenarios. The calculated plant-specific depletion coefficient is only utilized where it is lower than (i.e., more conservative) the WCAP-16406-P lower-limit values. Further evaluation was performed by Westinghouse for valves and flow restrictions that were initially determined to potentially wear beyond a 3% flow increase. This evaluation assumed a depletion coefficient of 0.07 for all depletable debris.
11.	TR WCAP-16406-P, Revision 1, Section 7.3.2.3, recognizes that material hardness has an effect on erosive wear. TR WCAP-16406-P, Revision 1, suggests that "For elastomers, the wear rate is at least one order of magnitude less than steel. Therefore, for soft-seated valves, divide the estimated wear rate of steel from above equations by 10 per Appendix F." The NRC staff agrees that the wear rates of elastomers are significantly less than for steels. However, the wear coefficient should be determined by use of a suitable reference, not by dividing the steel rate by a factor of 10.	Wear of elastomeric materials, reduced by a factor of 10, is not applicable to any of the downstream effects wear calculations.
12.	TR WCAP-16406-P, Revision 1, Section 8.1.1.2, "Evaluation of ECCS Pumps for Operation with Debris-Laden Water from the Containment Sump," states that "Sufficient time is available to isolate the leakage from the failed pump seal and start operation of an alternate ECCS or CSS train." Also, Section 8.1.3, "Mechanical Shaft Seal Assembly," states: "Should the cooling water to the seal cooler be lost, the additional risk for seal failure is small for the required mission time for these pumps." These statements refer only to assessing seal leakage in the context of pump operability and 10 CFR Part 100 concerns. A licensee should evaluate leakage in the context of room habitability and room equipment operation and environmental qualification, if the calculated leakage is outside that which has been previously assumed.	Non-mechanistic failure of an ECCS or CBS pump seal is considered as a single-failure in the plant design basis and is acceptable. The WCAP-16406-P attempts to justify failure of the seals due to recirculation debris, which is a potential common-mode failure. The pump seals at Seabrook have been evaluated as not susceptible to failure by debris-laden water. The LHSI pump seals recirculate seal cavity fluid while the IHSI, HHSI, and CBS pump seal injection of process fluid was evaluated as acceptable for long-term recirculation. Therefore the only potential failure that must be considered is an assumed single failure, which again is part of the existing design basis of the plant (bounded by a moderate energy line break in the pump room). There is a potential for debris to cause an increased leakage flow through the disaster bushing following that single-failure. A plant-specific evaluation of the ECCS and CBS pump disaster bushings was performed by Westinghouse. The evaluation concludes that if it is assumed that wear and failure of the primary seal could occur, the disaster bushing, would wear a negligible amount in 30 minutes, and that the leakage rate of the pump would be kept to an acceptable limit until the leakage could be isolated and another train of ECCS or CBS could be started.
13.	TR WCAP-16406-P, Revision 1, Section 8.1.3, discusses cyclone separator operation. TR WCAP-16406-P, Revision 1, generically concludes that cyclone separators are not desirable during post-LOCA operation of HHSI pumps. The NRC staff does not agree with this generic statement. If a licensee pump contains a cyclone separator, it should be evaluated within the context of both normal and accident operation. The evaluation of cyclone separators is plant-specific and depends on cyclone separator design and the piping arrangement for a pump's seal injection system.	The LHSI, IHSI, HHSI, and CBS pump seals do not use cyclone separators in the seal injection lines.

L&C No.	NRC Limitations & Conditions: WCAP 16406-P Revision 1	Seabrook Response to L&C
14.	TR WCAP-16406-P, Revision 1, Section 8.1.4, refers to pump vibration evaluations. The effect of stop/start pump operation is addressed only in the context of clean water operation, as noted in Section 8.1.4.5 of TR WCAP-16406-P, Revision 1. If an ECCS or CSS pump is operated for a period of time and builds up a debris "packing" in the tight clearances, stops and starts again, the wear rates of those areas may be different due to additional packing or imbedding of material on those wear surfaces. Licensees who use stop/start operation as part of their overall ECCS or CSS operational plan should address this situation in their evaluation.	The pump wear analysis assumes 30 days of continuous wear. Seabrook procedure does not direct to stop then start the ECCS/CBS pumps during recirculation. In the event the pumps must be stopped and restarted, the Archard wear model assumed the highest friction factors and eccentricity postulated by the WCAP-16406-P. Therefore, any "additional packing" that could be caused by stopping and starting the pumps is bounded by the Archard model used.
15.	TR WCAP-16406-P, Revision 1, Section 8.1.4, states: "should the multistage ECCS pumps be operated at flow rates below 40% of BEP during the containment recirculation, one or more of the pumps should be secured to bring the flow rate of the remaining pump(s) above this flow rate." The NRC staff does not agree with this statement. System line-ups and pump operation and operating point assessment are the responsibility of the licensee. Licensees must ensure that their ECCS pumps are capable of performing their intended function and the NRC has no requirements as to their operating point during the recirculation phase of a LOCA.	The plant's procedures were not changed to reflect the WCAP-16406-P concerns. The Seabrook multistage pumps performed adequately with respect to pump design and plant design basis before GSI-191 concerns. The pump assessment concludes that the IHSI and HHSI pumps continue to be capable of performing their intended design basis functions based on the pump's hydraulic characteristics after 30 days of wearing.
16.	TR WCAP-16406-P, Revision 1, Section 8.1.5, makes a generic statement that all SI pumps have wear rings that are good "as new" based solely upon "very little service beyond inservice testing." A stronger basis is needed to validate this assumption, if used (e.g., maintenance, test and operational history and/or other supporting data).	The pump wear analysis assumed a starting wear ring clearance as the average of the vendor recommended gap range. The combination of low run time and very clean fluids would justify an assumption that the wear rings are "as good as new" and thus closer to the low end of the recommended ring clearance, but the wear calculation conservatively assumes that the wear rings are mid-way between the lower and the upper ring clearance recommended by the pump manufacturers.
17.	TR WCAP-16406-P, Revision 1, Section 8.3, identifies criteria for consideration of tube plugging. Licensees should confirm that the fluid velocity going through the heat exchanger is greater than the particle settling velocity and evaluate heat exchanger plugging if the fluid velocity is less than the settling velocity.	The minimum heat exchanger tube velocity was calculated and compared to the bounding particle settling velocity. No heat exchangers were found to be susceptible to debris settling within the tubes.
18.	TR WCAP-16406-P, Revision 1, Section 8.6, refers to evaluation of instrumentation tubing and system piping. Plugging evaluations of instrument lines may be based on system flow and material settling velocities, but they must consider local velocities and low-flow areas due to specific plant configuration.	The evaluation of instrumentation tubing was based primarily on the instrument line's specific configuration, and then upon the local flow velocity if instrument lines were oriented below the horizontal datum. Plant-specific layout and actual local flow velocities were used in all cases.
19.	TR WCAP-16406-P, Revision 1, Sections 8.6.7, 8.6.8, 8.6.9, and 8.6.10 describe, in general terms, the Westinghouse, CE, and B&W RVLIS. TR WCAP-16406-P, Revision 1, recommends that licensees evaluate their specific configuration to confirm that a debris loading due to settlement in the reactor vessel does not effect the operation of its RVLIS. The evaluation of specific RVLIS design and operation is outside the scope of this SE and should be performed in the context of a licensees reactor fuel and vessel evaluations.	The Seabrook RVLIS design was compared to the generic designs reviewed and deemed acceptable by the WCAP-16406-P. The plant design was found to be consistent, and therefore it is expected to be acceptable with regards to recirculation operation.

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20.	TR WCAP-16406-P, Revision 1, Section 8.7, refers to evaluation of system piping. Plugging evaluations of system piping should be based on system flow and material settling velocities. Licensees should consider the effects of local velocities and low-flow areas due to specific plant configuration. A piping wear evaluation using the free-flowing wear model outlined in Section 7 should be performed for piping systems. The evaluation should consider localized high-velocity and high-turbulence areas. A piping vibration assessment should be performed if areas of plugging or high localized wear are identified.	ECCS and CBS system piping was checked for potential plugging due to debris settling. At each control valve in the recirculation systems, the minimum expected system flow rates in each line were used to minimize the flow velocity and compared to the bounding settling velocity. The evaluation at control valve locations considered the local flow velocities of all the lines used for recirculation in the Seabrook ECCS and CBS. All lines were found acceptable with respect to plugging. Regarding wear, the material wear of the bounding orifice in each of the HHSI, IHSI, LHSI, and CBS systems, which sees much higher wear than system piping, was compared to the pipe wall thicknesses in the recirculation lines of those systems. The material wear was found to be insignificant compared to the pipe wall thickness. Therefore, all pipes were determined to have sufficient wear margin, and the erosion was considered so slight as to not require vibration analysis.
21.	TR WCAP-16406-P, Revision 1, Section 9, addresses reactor internal and fuel blockage evaluations. This SE summarizes seven issues regarding the evaluation of reactor internal and fuel. The PWROG indicated that the methodology presented in TR WCAP-16793-NP (Reference 15) will address the seven issues. Licensees should refer to TR WCAP-16793-NP and the NRC staff's SE of the TR WCAP-16793-NP, in performing their reactor internal and fuel blockage evaluations. The NRC staff has reached no conclusions regarding the information presented in TR WCAP-16406-P, Section 9.	Reactor internals and fuel blockage was evaluated utilizing WCAP-16793-NP and is addressed in response to Topic 3.n, Downstream Effects – Fuel and Vessel.
22.	TR WCAP-16406-P, Revision 1, Table 4.2-1, defines a plant Category based on its Low-Head / Pressure Safety Injection to RCS Hot-Leg Capability. Figure 10.4-2 implies that Category 2 and 4 plants can justify LHSI for hot-leg recirculation. However, these categories of plants only have one hot-leg injection pathway. Category 2 and Category 4 plant licensees should confirm that taking credit for the single hot-leg injection pathway for their plant is consistent with their current hot-leg recirculation licensing basis.	This WCAP-16406-P guidance was not utilized. Seabrook has single-failure tolerant hot-leg recirculation capability as part of the existing design and licensing basis. No credit was taken for a single hot-leg injection pathway as suggested by the WCAP-16406-P.
23.	TR WCAP-16406-P, Revision 1, Appendix F, discusses component wear models. Prior to using the free-flowing abrasive model for pump wear, the licensee should show that the benchmarked data is similar to or bounds its plant conditions.	The debris and wear models were conservatively applied to ensure that they conservatively predict expected wear. Actual pump dimensions, characteristics, and materials, and the actual plant debris concentration was utilized in predicting pump wear.
24.	TR WCAP-16406-P, Revision 1, Appendix H, references American Petroleum Institute (API) Standard 610, Annex 1 eighth edition. This standard is for newly manufactured pumps. Licensees should verify that their pumps are "as good as new" prior to using the analysis methods of API-610. This validation may be in the form of maintenance records, maintenance history, or testing that documents that the as-found condition of their pumps.	The pump calculations all assume that the starting point for the wear rings is the midpoint of the manufacturers recommended ring clearance (see #16, above). Since the pumps rings are in new condition, the analysis methods of API-610 are applicable.
25.	TR WCAP-16406-P, Revision 1, Appendix I, provides guidelines for the treatment, categorization and amount of DBA Qualified, DBA Acceptable, Indeterminate, DBA Unqualified, and DBA Unacceptable coatings to be used in a licensee's downstream sump debris evaluation. A technical review of coatings generated during a DBA is not within the scope of this SE. For guidance regarding this subject see the NRC staff's SE of NEI-04-07 (Reference 13) Section 3.4 "Debris Generation."	This SER limitation is simply a statement of the limit of the NRC's review; no action is required. For reference, however, the amount of specific types of coatings used in the downstream effects analysis was determined on a plant-specific basis considering the types of coatings actually in use in the Seabrook containment. The methodology of NEI 04-07 and the SER thereto was followed generally.

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26.	TR WCAP-16406-P, Revision 1, Appendix J, derives an approach to determining a generic characteristic size of deformable material that will pass through a strainer hole. This approach is only applicable to screens and is not applicable to determining material that will pass through other close tolerance equipment.	This approach that is "only applicable to screens" was only applied to the sump screens (strainers in the case of Seabrook). The characteristic size of debris that can pass through the sump strainer was calculated and then compared to the smallest passages of downstream components. The component was deemed acceptable where the smallest passage is larger than this characteristic size, in other words the deformation of the debris was not credited to allow it to pass the downstream close tolerances.
27.	TR WCAP-16406-P, Revision 1, Appendix O, Section 2.2, states that the wear coefficient, K, in the Archard Model is determined from testing. The wear coefficient (K) is more uncertain than the load centering approach and K may vary widely. Therefore, licensees should provide a clear basis, in their evaluation, for their selection of a wear coefficient.	The Archard model wear coefficient utilized in the Seabrook IHSI and HHSI pump wear analysis is the "conservative upper bound" suggested by the WCAP-16406-P and 5 times larger than the value actually used in the WCAP-16406-P example. Its use resulted in calculated wear greater than the amount seen in the Davis-Besse testing. The materials, debris types and concentrations are comparable. Therefore, the K-value used appears to be the best conservative information available on ECCS pump wear when exposed to insulation and coating debris.
28.	TR WCAP-16406-P, Revision 1, Appendix P, provides a method to estimate a packing load for use in Archard's wear model. The method presented was benchmarked for a single situation. Licensees are expected to provide a discussion as to the similarity and applicability to their conditions. The licensee should incorporate its own specific design parameters when using this method.	The methodology of Appendix P was not used in the determination of packing loads. The Seabrook calculation utilized the methodology discussed in Appendix O of WCAP-16406-P (centering load) for defining loads to be used in the packing wear model, and specific design parameters were applied to that methodology.
29.	TR WCAP-16406-P, Revision 1, Appendix Q, discusses bounding debris concentrations. Debris concentrations are plant-specific. If 9.02E-5 (mils/hr)/10 PPM is to be used as the free flowing abrasive wear constant, the licensee should show how it is bounding or representative of its plant.	9.02E-5 (mils/hr)/10 PPM was not used as the free flowing abrasive wear constant at the plant. The wear rate was calculated for each pump's actual material hardness and actual debris concentrations, including application of the bounding debris penalty as required.

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30.	TR WCAP-16406-P, Revision 1, Appendix R, evaluates a Pacific 11-Stage 2.5" RLIJ pump. The analysis was performed by the PWROG using specific inputs. ECCS pumps with running clearance designs and dimensions significantly different than those covered by the analysis should be subjected to pump-specific analysis to determine the support stiffness based on asymmetric wear. If licensees use the aforementioned example, a similarity evaluation should be performed showing how the example is similar to or bounds their situations.	Acceptance criteria and stiffness values from Appendix R were not used. All pump calculations utilize plant specific information and data to perform wear calculation and shaft stiffness evaluations. Example data from the WCAP-16406-P is not used in any calculation. The designs and dimensions of the Seabrook IHSI and HHSI pumps were reviewed and found to not be significantly different than those covered by the WCAP-16406-P analysis. Multi-stage pumps were evaluated by finding the shaft stiffness at a symmetric increase in wear ring clearance equal to 2X or 2.8X of the as-new clearance. The 2.8X criteria was applicable to the Seabrook HHSI pumps because they are 2.5" Pacific Pump Model RLIJ, eleven stage pumps. WCAP-16406-P Section 8.1.5 , Appendix H supports the conclusion that this pump model is acceptable for the 2.8X criterion. The Seabrook IHSI pumps were analyzed to the default 2X wear ring gap symmetric wear criterion. The stiffness of the pumps after debris induced wear was then calculated. The stiffness of the pumps after recirculation asymmetric wear was compared to the allowed stiffness equivalent to a uniform 2X or 2.8X initial clearance to judge the acceptability of the pump.
31.	Licensees should compare the design and operating characteristics of the Pacific 2.5" RLIJ 11 to their specific pumps prior to using the results of Appendix S in their component analyses.	The criteria and analysis specific for Pacific 2.5" RLIJ 11 as shown in Appendix S was used for the Seabrook HHSI pumps because they are the same model. Otherwise, as stated in response 30 above, all pump calculations utilize plant specific information and data to perform wear calculation and shaft stiffness evaluations. Example data from the WCAP-16406-P is not used in any calculation. Multi-stage pumps were evaluated by finding the shaft stiffness at a symmetric increase in wear ring clearance equal to 2X or 2.8X (for the HHSI pumps) of the as-new clearance. The stiffness of the pumps after debris induced wear was then calculated. The stiffness of the pumps after recirculation asymmetric wear was compared to the allowed stiffness equivalent to a uniform 2X or 2.8X initial clearance to judge the acceptability of the pump