UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 28, 2009

LICENSEES: Union Electric Company
Wolf Creek Nuclear Operating Corporation

FACILITIES: Callaway Plant, Unit 1
Wolf Creek Generating Station

SUBJECT: SUMMARY OF AUGUST 27, 2009, CATEGORY 1 MEETING WITH UNION ELECTRIC COMPANY AND WOLF CREEK NUCLEAR OPERATING CORPORATION – DISCUSSION OF REQUEST FOR ADDITIONAL INFORMATION FOR GENERIC LETTER 2004-02, "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS" (TAC NOS. MC4671 AND MC4731)

On August 27, 2009, a public meeting was held between the U.S. Nuclear Regulatory Commission (NRC), and representatives of Union Electric Company and Wolf Creek Nuclear Operating Corporation (the licensees), at NRC Headquarters, One White Flint North, 11555 Rockville Pike, Rockville, MD. The purpose of the meeting was to discuss the proposed response to requests for additional information (RAIs) for Callaway Plant, Unit 1 (Callaway), dated December 18, 2008, and Wolf Creek Generating Station (Wolf Creek), dated June 22, 2009 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML092010114 and ML091970418, respectively).

A list of meeting attendees is provided in Enclosure 1.

Results of Discussion

The licensees provided summarized information for the proposed responses applicable to both facilities, Callaway and Wolf Creek, and a copy of the document is provided as Enclosure 2 to this meeting summary. Wolf Creek RAIs were used as the basis for discussion. Since RAI numbers for Wolf Creek did not match with Callaway, a cross-reference matrix prepared by the Callaway licensee (Enclosure 3) was used to identify corresponding Callaway RAIs. The following were the results of the discussions:

1. The NRC staff expressed the view that the licensees are on a success path for the following RAIs based on the summary of their planned responses: RAIs 1, 2, 15, 18-20, 31, 34, 38, 40, 41, 45, 46, 48, and 49.

2. The NRC staff expressed the view that the licensees can demonstrate a success path of the following RAIs subject to providing additional information in the final RAI responses, as noted below on each RAI:

   - RAI 23: The proposed approach appears reasonable. However, the licensees need to show large debris pieces are interdicted and that washdown is not a problem.
   - RAI 36: The NRC staff's concern of debris addition to the test flume, without the recirculation pump running, is not likely to be a significant concern since most fines were added after pump start.
   - RAI 42: The licensees indicated that flashing will not occur. The licensees should justify this view and submit additional information to reinforce their position.
   - RAI 43: The licensees should include the information discussed during the meeting regarding temperature corrected head loss, the methodology for extrapolation and temperature scaling of the head loss, and the method used to determine total strainer head loss, in its final RAI response.
   - RAI 44: The licensees are requested to show that reactor coolant system holdup volume assumed in the analysis is conservative for the small-break case.
   - RAI 50: The licensees should support the assertion that NUKON, not assumed destroyed during the postulated event, is jacketed, assuming that this is the case.

3. The NRC staff agreed to provide feedback to the licensees on the following RAI responses:

   - RAI 17: The NRC staff will review PCI's white paper supplement on debris preparation available with J. Golla of NRC staff and provide feedback. The NRC staff also agreed to review the video to be submitted by the licensees.
   - RAI 21: The NRC staff will evaluate the supplemental responses and information provided during the meeting and provide feedback.
   - RAI 25: The NRC staff will review NUREG/CR-2982 and re-evaluate the licensees' responses.
   - RAI 37: Based on additional information provided during the meeting, the NRC staff will re-evaluate supplemental responses for this item. The licensees should state the chip size.
   - RAI 45: The NRC staff agreed to evaluate the validity of Alion Report "ALION-REP-TXU-4464-02" for its use as a reference in the supplemental responses and will provide feedback to the licensees.

4. The licensees agreed to discuss the responses to the following RAIs at a public meeting, tentatively planned for late November 2009:

   - RAIs 3-13 and 16: These items relate to generic discussions regarding credit for reduction in zone of influence. The licensees were requested to provide contingency plans for the eventuality if the NRC staff does not accept the reductions.
   - RAI 14: Not applicable to Wolf Creek. Callaway is presently evaluating the acceptability of the thermal wrap system and will discuss methods and results at the public meeting.
   - RAI 17: The licensees agreed to provide a copy of the video for the Alden Test showing separation of the fibrous debris in representative and conservative manner for NRC staff review.
   - RAI 21: The licensees indicated that small fines of fiber were assumed to transport 100 percent in the active recirculation pool. The NRC staff requested the licensees to discuss this matter in detail during the future public meeting.
   - RAI 22: The licensees indicated that the video for the Alden Test performed on August 18, 2009, may resolve the NRC staff's concerns. The NRC staff agreed to review the video before the future public meeting. However, the NRC staff expressed skepticism that the video will fully resolve NRC staff's concerns.
   - RAI 24: NRC staff requested the licensees to provide detailed information in the area of the tortuous path to sumps during the future public meeting. The licensees were also requested to explain curb lift velocities for debris carryover to the sumps.
   - RAI 26: The NRC staff stated it was not apparent that soaking of the debris prior to insertion to remove any air entrained on the surface of the debris is conservative. The licensees plan to discuss this matter at the proposed public meeting, that it is prototypical and that the amounts of debris involved would be small.
   - RAI 27: The licensees agreed to provide and discuss a figure showing the flow streams during the proposed public meeting.
   - RAI 28: The licensees discussed conservatisms in the debris preparation methodology used by its contractor, PCI. The NRC staff expressed concern with the justifications and requested the licensees to discuss this matter in more detail during the planned public meeting. The staff noted that the NRC was not satisfied with the rationale provided and the sub-bullets on debris preparation conservatisms in the RAI and that a rigorous justification would be needed.
   - RAI 29: The licensees plan to discuss the impact of overhead grating drainage sources near the sump strainers.
   - RAI 30: The licensees plan to describe the correlation of NUREG/CR-6916, "Hydraulic Transport of Coating Debris," and its application to Callaway and Wolf Creek strainer analysis as described in the information provided during the meeting. The licensees may show the impact of the assumption is small.

- RAI 32: The licensees plan to address whether the two-train case leads to more fines and is expected to provide a basis for conclusion that for the single-train case, increased debris loading would be more significant than reduced sump approach velocity.
- RAI 33: Since the concerns stated by this RAI are being addressed by responses to other RAIs, the NRC staff requested the licensees to provide cross references to other RAIs where the concerns are addressed (RAIs 17 and 28).
- RAI 35: After discussions, the licensees stated that they misunderstood the question and will re-evaluate and provide response at the next public meeting.
- RAI 37: As stated under item 3 above, the NRC staff will provide feedback to the licensees based on the additional information provided during the meeting. This RAI will also be discussed during the planned public meeting.
- RAI 39: The NRC staff suggested that the licensees use a curve that bounds the head loss data. The licensees plan to re-evaluate and provide response during the future public meeting.

5. During the meeting, the Callaway licensee confirmed that Wolf Creek RAIs apply to and will be addressed by Callaway. In addition, the NRC staff verified that all Callaway RAIs were either equivalent to Wolf Creek RAIs or were discussed separately. The Callaway licensee discussed the status of the following additional Callaway RAIs that did not clearly cross reference to Wolf Creek RAIs:

   - RAIs 11 and 19: The NRC staff considered the proposed response by the licensee to be adequate.
   - RAIs 15-16: The licensee plans to mimic Wolf Creek's response to similar items.
   - RAI 2: The licensee plans to make licensing and physical arguments regarding its approach to main steam line break and justify that large-break loss-of-coolant accident is bounding from a debris generation standpoint.

There were no questions from the members of the public. Also, no Public Meeting Feedback forms were received for this meeting.

Please direct any inquiries to me at (301) 415-3016 or Balwant.Singal@nrc.gov.

Sincerely,

Michael Markley for

Balwant K. Singal, Senior Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-482 and 50-483

Enclosures:
1. List of Attendees
2. Proposed Approach to RAI Responses
3. Callaway and Wolf Creek RAI Cross-reference Matrix

cc w/encl: Distribution via Listserv (Callaway and Wolf Creek)

ENCLOSURE 1

LIST OF MEETING ATTENDEES AND BRIDGE LINE PARTICIPANTS

AUGUST 27, 2009, PUBLIC MEETING WITH

UNION ELECTRIC COMPANY AND

WOLF CREEK NUCLEAR OPERATING CORPORATION

LIST OF ATTENDEES IN PERSON FOR AUGUST 27, 2009
PUBLIC MEETING WITH UNION ELECTRIV COMPANY AND
WOLF CREEK NUCLEAR OPERATING COMPANY

NAME	ORGANIZATION
Balwant K. Singal	NRR/DORL/LPL4
Mohan Thadani	NRR/DORL/LPL4
Michael Scott	NRR/DSS/SSIB
Steve Smith	NRR/DSS/SSIB
John Lehning	NRR/DSS/SSIB
Chris Hott	NRR/DSS

LIST OF ATTENDEES VIA CONFERENCE CALL FOR August 27, 2009
PUBLIC MEETING WITH UNION ELECTRIC COMPANY AND
WOLF CREEK NUCLEAR OPERATING CORPORATION

NAME	ORGANIZATION
Union Electric Company (AmerenUE), Wolf Creek Nuclear Operating Corporation (WCNOC) and Supporting Organizations	
Ron Holloway	WCNOC
Paul Nabb	WCNOC
M. Stachowiak	WCNOC
Mo Dingler	PWROG/WCNOC
Ken Peterson	STARS
Tom Elwood	AmerenUE
Brian Holderness	AmerenUE
Matt Brandes	AmerenUE
J. Bleigh	PCI
C. Kudla	PCI
T. Anselmi	Alion
T. Sande	Alion
J. Tezak	Alion
S. Cain	Alden
L. Haber	Alden

ENCLOSURE 2

PROPOSED APPROACH TO RAI RESPONSES

DISCUSSED DURING AUGUST 27, 2009, PUBLIC MEETING WITH

UNION ELECTRIC COMPANY AND

WOLF CREEK NUCLEAR OPERATING CORPORATION

PROVIDED BY WOLF CREEK VIA E-MAIL ON AUGUST 27, 2009

Talking Points for
August 27 NRC telecon with
Wolf Creek & Callaway

RAI #1

- Loops are relatively symmetrical except loop D
- Loop D had the highest quantity of fiber due to the Pzr surge line

RAI Q 1.

Please verify that the insulation types and amounts are distributed relatively symmetrically between all loops to validate that the focus on loop D provided a conservative break selection evaluation, or otherwise justify the assumption.

RAI #2

- Re-assessed water level and strainer submerged (1'-10" water level – so approximately 8 inches submerged for SBLOCA)
- 3" is bounding for breaks with the least amount of inventory:
  - Larger breaks would result in more inventory
    - CTMT spray
    - Accumulators
    - RCS blowdown
  - Alternate charging line generates most debris based on analysis
    - 3" alternate charging line, 10" SIS accumulator injection and 1½" boron injection lines within a 1.53 ft radius

RAI Q 2.

Please justify that the 3-inch charging line break provides the greatest debris generation for the partially submerged conditions. Please state whether there other breaks, potentially on larger lines, that could result in a larger debris term, yet still result in partial submergence. Please provide results of evaluations and testing that verify that the debris generated by the limiting break that results in partial submergence will not result in unacceptable head loss (strainer failure). Please either state that this evaluation is based on a U.S. Nuclear Regulatory Commission (NRC) staff-accepted test methodology or justify use of a different methodology. Note that the NRC staff considers testing conducted at Alden Labs prior to 2008 likely to be non-conservative. Alternately, please verify that the strainer will be fully submerged for all small break loss-of-coolant accident (SBLOCA) conditions as described on page 47 of the December 22, 2008, supplemental response (Agencywide Documents Access and Management System (ADAMS) Accession No. ML090060877), such that the large break loss-of-coolant accident (LBLOCA) testing bounds the SBLOCA.

RAI #3 - #13

- The PWROG will be responding to this RAI generically. Following staff acceptance of the PWROG's generic resolution, WCNOC and AmerenUE will respond to this RAI based on the generic resolution and will add site-specific information as appropriate.

RAI Q 3-13

Please respond to the following questions on debris generation testing. Note that the Pressurized-Water Reactor Owners Group (PWROG) is planning to respond to some of these issues generically. The licensee will be expected to respond to all of them. To the extent the NRC staff accepts the PWROG's generic resolution, the licensee's request for additional information (RAI) responses may refer to the resolution document as appropriate, while adding site-specific information as needed.

RAI #14

- Wolf Creek
  - Not applicable to WCGS. Not installed in containment at Wolf Creek.
- Callaway
  - Analysis is in process to justify acceptability of the Thermal-Wrap system. Options will be considered when analysis is complete.

RAI Q 14.

Please provide a comparison of the Thermal-Wrap and Nukon insulation systems that justifies that the Thermal-Wrap system is at least as structurally robust as the Nukon. The licensee's response only describes the similarity of the base material fibers and claims similarity was asserted in the NRC staff's safety evaluation (SE) dated December 6,2004 (ADAMS Accession No. ML043280641), on NEI 04-07. This conclusion in the SE was reached on the basis of a large 17D ZOI being assumed, one that was likely conservative for both materials, whether the jacketing is similar or perhaps even present. However, when conservatisms are removed to arrive at a smaller ZOI (i.e., effectively 5D), it becomes necessary to demonstrate similarity of the jacketing, banding, scrim, and cloth covers to show sufficient similarity. Based on testing done by Westinghouse/Wyle for Arkansas Nuclear One (ANO) (Entergy Operations, Inc. letter dated February 28, 2008, ADAMS Accession No. ML08071 0544), some damage was seen for Thermal Wrap at 12D and at 7D, which suggests a potential for increased vulnerability. It was not clear to the NRC staff why this Thermal Wrap test is not more applicable to the Thermal Wrap at WCGS than a test performed for a different material (i.e., Nukon). Therefore, please justify treating Thermal Wrap with a reduced ZOI based on Nukon testing, in terms of the jacketing, banding and/or latching, scrim, and cloth cover for the Thermal Wrap insulation to provide confidence that it is comparable to the jacketing system for the Nukon insulation system that was tested.

RAI #15

- While issues associated with ZOI testing are currently ongoing, the following information addresses the current WC/CNP analyses.
- Tested to a site specific dimension due to restraints for RCPs and S/Gs
  - Zero gap (movement) at NOP/NOT for RCP and S/G restraints
  - Wagon wheel (Pipe whip restraints)
    - This restraint limits lateral movement of the piping should a break occur at the nozzle welds.
- Based on the above, the potential 1/8" offset break is conservative.
- Other breaks, e.g., a longitudinal break would produce a similar directed jet.
- A possible longer blowdown period would not lead to Min-K insulation being ejected as debris since the insulation is encapsulated in a welded stainless steel material and jet impingent forces would continue to decrease.

RAI Q 15.

The supplemental response dated February 29, 2008 (pg 14 of 82), stated that the Min-K at WCGS is located near the reactor vessel. Please state whether spherical resizing was performed for the Min-K ZOI and, if so, justify that it is appropriate for this location considering that substantial physical obstructions could result in a significantly non-spherical ZOI. The NRC staff's May 16, 2007, audit report for San Onofre Nuclear Generating Station discusses a potentially similar issue (Open Item 1 in Section 3.2, ADAMS Accession No. ML071240024) regarding Microtherm insulation that was located on the reactor vessel, for which spherical resizing was considered inappropriate by the NRC staff due to the constraints imposed by the biological shield wall and reactor vessel. The WCAP report states that a 1/8-inch offset was assumed rather than full separation for the Min-K break thus spherical scaling would not have been specified per the ANSI/ANS-58-2-1988 model. The supplemental response and debris generation test report do not discuss how the scaling for the 1/8-inch offset case is handled. It is not clear that the ANSI/ANS-58-2-1988 (non-spherical) model for the limited separation case was done for the Min-K. Please justify that an offset circumferential break is the only type of break necessary to consider, or provide results of evaluations of other configurations. For example, should a longitudinal break be postulated? If the Min-K is damaged by a restrained break, please justify that a 30-second duration jet impingement is adequate to model the blowdown from the break. Please explain and justify whether the blowdown should be longer for a restrained break with a smaller effective break area.

RAI #16

- The debris size distribution used is based on the results of WCAP-16710.
- Ongoing evaluations are underway to justify debris size distribution.

RAI Q 16.

The assumed debris size distribution of 60 percent small fines and 40 percent large pieces for low-density fiberglass within a 5D ZOI is inconsistent with Figure 11-2 of the NRC staffs SE dated December 6, 2004 (ADAMS Accession No. ML043280641), on NEI 04-07, which considers past air jet testing and indicates that the fraction of small fines should be assumed to reach 100 percent at jet pressures in the vicinity of 18-19 pounds per square inch (psi). At 5D, the jet pressure is close to 30 psi, which significantly exceeds this threshold. Furthermore, the licensee's assumption that the size distribution for debris in a range of 5D to 7D is 100 percent intact blankets also appears to be inconsistent with existing destruction testing data. These assumptions for low-density fiberglass debris size distributions appear to be based on the recent Westinghouse Wyle ZOI testing discussed in WCAP-16710-P. However, that testing was not designed to provide size distribution information, and much of the target material was exposed to jet pressures much lower than would be expected for a prototypically sized break. Furthermore, given the assumption that insulation between 5D and 7D is 100 percent intact pieces that do not transport or erode, the licensee has effectively assumed a 5D ZOI rather than a 7D ZOI for low-density fiberglass. In light of the discussion above concerning previous testing experience, please provide a basis for considering the assumed debris size distribution of 60 percent small fines and 40 percent large pieces within a 5D ZOI to be conservative or protypical.

RAI #17

- The 30% of the small pieces ("small fines" mixture) added to the head loss test was in the form of individual fibers based on an examination of a sample of the small pieces that were used during the head loss test.
- Recent more-detailed sampling by PCI as documented in PCI's recent white paper supplement on debris preparation supports the position that the small fines mixture contains more than 30% individual fibers.
- The video of the Alden test implemented August 18, 2009 has confirmed separation of fibers upon introduction did occur in a representative and conservative manner as is expected in the post LOCA plant condition. Video will be provided.
- Refer to RAI #34 for quantity of fines.

RAI Q 17.

The NEI 04-07, along with the NRC staff SE on that document, provides information regarding the treatment of the characteristics of fibrous debris generated from a break. The guidance report states that small fines are individual fibers. However, the staff SE notes that this is likely to result in problems in the treatment of fibrous debris. The amount of fines and small pieces of debris should be defined separately so that inputs for transport analyses and head loss testing are well defined. The estimation of fine debris amounts is especially important for testing that allows near-field settling. The guidance documents, such as Appendix II to the SE on NEI 04-07, indicate that reduced ZOIs generally result in increased percentages of small and fine debris. The supplemental response dated December 22, 2008, stated that 30 percent of the small fibrous debris added to the head loss test was estimated to be in the form of fines, but the response did not provide a basis for this assumption, such as an analytical evaluation of expected quantities of the plant fibrous debris determined to be fines. The ZOI reduction taken for Nukon should reflect the phenomenon demonstrated in SE Appendix II of increased debris fragmentation near the break location when the debris sizing is estimated, or the licensee should justify otherwise. Please identify the amounts of fine fibrous debris predicted to be generated from the analyzed limiting breaks.

RAI #18

- Neither Cerablanket nor Foamglas are debris types in the limiting debris load case for WCGS
  - Both had a SER maximum of 28.6D ZOI in the analysis
- Similar for AlphaMatD at Callaway
  - Had a SER maximum of 28.6D ZOI in the analysis and not part of the bounding debris case

RAI Q 18.

To the extent Foamless and Cerablanket are included in the limiting debris loading case, please provide an evaluation of their characteristics, such as characteristic size distribution (small pieces and fines, etc.) and density, and please provide justification for deviation from staff-approved evaluation methodologies.

RAI #19

- Refer to Figure 3e.5 of WCNOC response, ML080700356
- The SER limits the fraction of debris moving into inactive pools to "a maximum of 15% of the source term", which is 15% of the total quantity of debris generated.
- From the logic trees for fiberglass, this amounts to a transport fraction of: [(Small Fines Debris Generated) x (20% not blown to upper containment) x (15% washed to reactor cavity)] + [(Small Fines Debris Generated) x (20% not blown to upper containment) x (14% washed to inactive sump cavity)], or 6% of the source term.
- Thus, WC/CNP calculated debris transport to inactive cavities conservatively, and as guided by and within the bounds of the SER.

RAI Q 19.

The NRC staff's December 6, 2004, SE for NEI 04-07 states that a maximum of 15 percent holdup of debris should be assumed in inactive holdup regions during pool fill up. For the case of single-train sump operation for WCGS, a two-sump plant, the sump that is not operating essentially becomes an inactive holdup region. From this point of view, the staff observed that WCGS appeared to credit a 15 percent inactive holdup volume in the containment pool, plus 14 percent holdup in the inactive recirculation sump for single-train cases, for a total of 29 percent of debris held up in inactive volumes for these single-train cases (e.g., the Loop D cross-over break, the case considered by the licensee to be bounding). The staff considers this credit a deviation from the approved guidance in the SE, which stated that the limit for inactive hold up should be 15 percent unless a computational fluid dynamics (CFD) analysis was performed that considered the time-dependent containment pool flows during pool fill up. Please provide additional basis for the assumed total inactive holdup fraction of 29 percent or revise this value to within the accepted SE range.

RAI #19 Con't

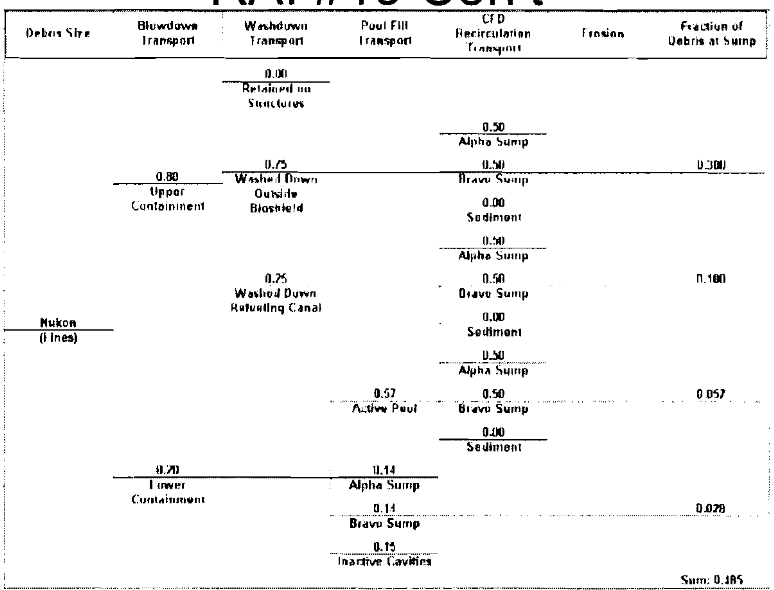


Figure 3e-5. Logic tree for NUKON™ fine debris to Bravo Sump

RAI Q 19.

The NRC staff's December 6, 2004, SE for NEI 04-07 states that a maximum of 15 percent holdup of debris should be assumed in inactive holdup regions during pool fill up. For the case of single-train sump operation for WCGS, a two-sump plant, the sump that is not operating essentially becomes an inactive holdup region. From this point of view, the staff observed that WCGS appeared to credit a 15 percent inactive holdup volume in the containment pool, plus 14 percent holdup in the inactive recirculation sump for single-train cases, for a total of 29 percent of debris held up in inactive volumes for these single-train cases (e.g., the Loop D cross-over break, the case considered by the licensee to be bounding). The staff considers this credit a deviation from the approved guidance in the SE, which stated that the limit for inactive hold up should be 15 percent unless a computational fluid dynamics (CFD) analysis was performed that considered the time-dependent containment pool flows during pool fill up. Please provide additional basis for the assumed total inactive holdup fraction of 29 percent or revise this value to within the accepted SE range.

RAI #20

- After analysis, all fine debris assumed to stay in suspension
  - No credit was taken using Stokes Law velocities
- Stokes Law was initially used to determine settling velocities

RAI Q 20.

The licensee's supplemental responses, including the one dated December 22,2008, discuss crediting Stokes' Law, but do not specifically quantify the credit taken for application of this methodology. Please state the quantities of fine debris assumed to settle onto the containment floor by applying the Stokes' Law methodology. If credit is taken for such settling, please provide technical justification regarding the following points: (1) lack of experimental benchmarking of analytically derived turbulent kinetic energy (TKE) metrics; (2) uncertainties in the predictive capabilities of TKE models in CFD codes, particularly at the low TKE levels necessary to suspend individual fibers and 10-micron particulate; (3) the basis for analytical prediction of settling velocities in quiescent and non-quiescent water due to the specification of shape factors and drag coefficients for irregularly shaped debris; and (4) the basis for the theoretical correlation of the terminal settling velocity to turbulent kinetic energy that underlies the Alion Science &Technology methodology for fine debris settling. Please address these points to demonstrate that any credit taken for fine debris settling is technically justified.

RAI #21

- The small fines of fiber at WC/CNP were assumed to transport 100% in the active recirculation pool. Therefore, only large pieces of fiber were subject to the 10% erosion.
- The flow conditions (velocity), chemical conditions, and fibrous material of the generic fiber erosion testing were conservative with respect to the WC/CNP plant conditions.
- The erosion test was performed at a higher bounding velocity than the recirculation pool. Flume velocity was based on recirculation pool velocity.

RAI Q 21.

Please provide a description of the testing performed to support the assumption of 10 percent erosion of fibrous debris pieces in the containment pool. Please specifically include the following information:

a. Please describe the test facility used and demonstrate the similarity of the flow conditions (velocity and turbulence), chemical conditions, and fibrous material present in the erosion tests to the analogous conditions applicable to the plant condition.

b. Please provide specific justification for any erosion tests conducted at a minimum tumbling velocity if debris settling was credited in the test flume for velocities in excess of this value (e.g., in front of the curb around the sump pit).

c. Please identify the duration of the erosion tests and how the results were extrapolated to the sump mission time.

RAI #22

- The head loss testing for WC/CNP did model the erosion of this debris due to increased velocities from the decreased flow area.
- The small fines used contained more than 30% fines – see RAI # 17
- The video of the Alden test implemented August 18, 2009 has confirmed separation of fibers upon introduction did occur in a representative and conservative manner as is expected in the post LOCA plant condition. Video will be provided.

RAI Q 22.

The supplemental response dated December 22, 2008, indicates that a significant percentage of small and large pieces of Nukon were assumed to transport to the strainers (i.e., nearly 100 percent of small pieces and approximately 75 percent of large pieces in several cases). This analytical result minimized the quantity of settled small and large pieces of fiberglass that were analytically assumed to erode in the containment pool. However, for the strainer head loss testing conducted by Performance Contracting, Inc. (PCI), the NRC staff considers it likely that a significant fraction of small pieces and most or all of the large pieces of debris that were analytically considered transportable actually settled in the test flume rather than transporting to the test strainer. The head loss testing did not model the erosion of this debris. The licensee's consideration of debris erosion, therefore, appears to be non-conservative, because neither the analysis nor the head loss testing accounted for the erosion of debris that settled during the head loss testing. Please estimate the quantity of eroded fines from large and small pieces of fiberglass debris that would result had erosion of the settled debris in the head loss test flume been accounted for and justify the neglect of this material in the head loss testing program.

RAI #23

- Design features would minimize pool fill transport:
  - Barrier doors at A and D loop entrances, the two potential flow paths with the most direct access to the strainers.
  - Long tortuous flow paths (approx. 180 ft.) out the B and C loop entrances, around the annulus, to the sumps.
  - 6" curb around the sumps.
  - Once small volume of sumps is filled, there is no preferential flow to the sumps.
- An amount of fibrous fines, to represent the potential latent fiber near the strainers at the start of the LOCA, was added into the test flume prior to pump start.

RAI Q 23.

Based upon discussions with the licensee and PCI in January and February 2008, the head loss testing conducted by PCI modeled flow conditions during the recirculation phase of a LOCA and modeled all debris (other than a small quantity of latent debris added with the recirculation pump stopped) as entering the containment pool one flume-length (nominally 33 feet) away from the containment sump strainers. Flow conditions during the pool-fill phase of the LOCA were not considered by the testing, nor was the potential for debris to enter the containment pool closer than one flume-length from the strainer due to the effects of blowdown, washdown, and pool fill transport. The lack of modeling of these two transport aspects of the head loss testing appeared to result in a non-prototypical reduction in the quantity of debris reaching the test strainer and, ultimately, non-conservative measured head loss values. Please provide the technical basis for not explicitly modeling transport modes other than recirculation transport, considering the following points:

a. As shown in Appendix III of the NRC staff's SE on NEI 04-07, containment pool velocity and turbulence values during fill up may exceed those during recirculation, due to the shallowness of the pool. Some debris that would not transport during recirculation may transport during the pool-fill phase. In addition, latent debris on the containment pool floor could be stirred into suspension by these high-velocity, turbulent flows, unlike the latent debris added to the quiescent PCI flume.

b. The pool fill phase will tend to move debris from inside the shield wall into the outer annulus away from the break location and nearer to the recirculation sump strainers.

c. For plants that have strainers located below the floor grade level, the transport of large and small pieces of debris during pool fill can result in this debris accumulating directly on the strainer surfaces, potentially resulting in the formation of a limiting debris layer at the entrance to the sump pit.

d. Representatively modeling the washdown of some fraction of the debris nearer the strainer than one flume-length away would be expected to increase the quantity of debris transported to the strainer and the measured head loss. This statement applies both to debris that tends to settle in the head loss test flume, as well as debris considered to settle analytically, such as various types of paint chips.

RAI #24

- Same for #23 with regard to barriers
- Long tortuous path to sumps (~180 ft each). Water would get there fast with some small debris, but not large debris. Sumps are filled rather quickly and water would become still until recirculation.

RAI Q 24.

Please provide the technical basis for the conclusion that large pieces of fibrous debris and, as applicable, reflective metal insulation (RMI) debris, coating chips, and other debris types, have a transport fraction of zero during the pool-fill phase of a LOCA.

RAI #25

- NUREG/CR-2982 provides better and more recent information for this issue (e.g. floating fiberglass debris) than NUREG/CR-2791 since NUREG/CR-2982 provides a description and results of actual testing.
- NUREG 2982 shows Nukon will readily absorb hot water and sink rapidly.
- Significant structures, barriers, components in the way will prevent or slow down the transport of large or intact pieces to the sumps to allow settling.

RAI Q 25.

The supplemental response dated December 22, 2008, states that, based on testing documented in NUREG/CR-2791, "Methodology for Evaluation of Insulation Debris Effects, Containment Emergency Sump Performance Unresolved Safety Issue A-43," dated September 1982, Nukon was assumed not to float on the surface of the containment pool. However, page 51 of NUREG/CR-2791 indicates that large floating fragments of fiberglass under hot (60°C) sprays will sink in 2 to 5 days. As a result, NUREG/CR-2791 stated that it is reasonable to assume that all large floating fragments of fiberglass sink in the vicinity of the strainers. In light of these test results from NUREG/CR-2791, please provide additional basis for the assumption that large or intact pieces of fiberglass debris cannot float for a sufficient period of time to reach the strainers prior to sinking in the containment pool. If floating debris sinks on strainers located in a sump pit, there is the potential for forming a limiting layer of debris at the entrance to the strainer pit.

RAI #26

- Testing for transport of miscellaneous debris was conducted, with the pump running.
- Debris was soaked prior to insertion to remove any air entrained on the surface of the debris.
- The debris was inserted at the surface of the water in the drop zone, oriented parallel to the surface of the water to maximize the time the debris would remain in suspension.
- Any of the debris that was shown to float or transport was included in subsequent head loss testing.
  - Non-transported debris would have trapped transportable debris and was not included in testing to be more conservative.

RAI Q 26.

The supplemental response dated December 22,2008, indicates that most miscellaneous debris settled prior to reaching the test strainer. Based on previous observations of other testing performed at PCI, the NRC staff observed that tags, labels, and miscellaneous materials were added to the test flume by submerging them beneath the surface of the test fluid. Submerging miscellaneous debris would not allow the potential for transport to the strainers by floatation to be evaluated. Due to the pit strainer configuration at WCGS, if miscellaneous debris can float toward the strainers and subsequently sink over the strainers, then part of the opening to the strainer pit could be blocked off. Please describe the addition process for miscellaneous debris (e.g., tags, labels, and stickers), and discuss how the potential for transport via floatation was considered in the head loss testing program or by analysis.

RAI #27

- Significant flow channeling or distortion is not observed at the selected detailed CFD boundaries
- Selected locations show uniform flow and perpendicular velocity direction
- The boundary conditions were correctly extracted and applied for detailed CFD calculations

RAI Q 27.

Based on discussions with the licensee and PCI in January and February 2008, the NRC staff considered the modeling of the boundary conditions for the localized CFD model for the vicinity of the sump strainers to be non-conservative. Although the total flow rate from each side of the annulus was taken from the full-containment CFD model by using a constant, averaged velocity boundary condition, the localized CFD model did not simulate the significant channeling of the flow predicted by the full-containment model. As a result, velocities in the vicinity of the strainer were significantly underestimated. Since the localized CFD model was used as the basis for the head loss test flume velocities, the staff considered the test flume velocities as underestimating the velocities at which much of the debris would actually transport to the plant sump strainers. Although the staff recognized that some improvements had been made to the localized CFD model (e.g., a finer mesh resolution), these improvements did not compensate for the inaccuracy in the specification of the inlet boundary conditions. Please provide any information in addition to the information already discussed with the staff that could demonstrate the adequacy of the flow conditions used for the head loss test.

RAI #28

- The amount of fines in the small fines mixture was determined by measuring a sample, not a visual estimation – also see RAI #17
- PCI's recent white paper supplement on debris preparation supports the position that the small fines mixture contains more than 30% individual fibers.
- Other debris preparation conservatisms;
  - PCI prepared all fibrous debris in a very conservative manner compared to the NEI guidelines.
  - A very high percentage of PCI's "smalls" debris meets the classification for "fines" by meeting the size classification of Class 1, 2 & 3 fibers defined in NUREG CR/6808.
  - The introduction of segregated "fines" before other fiber debris forms and onto the surface of the water column further increases the conservatism of transportation during large flume head loss tests, compared to the prototypical entrainment during recirculation flow.
- Although some agglomeration of fine fibrous debris was observed during introduction of the fibrous debris during the Wolf Creek / Callaway testing (which is considered to be prototypical of the post-LOCA containment), the video from the Alden test implemented August 18, 2009 has confirmed separation of fibers upon introduction did occur in a representative and conservative manner as is expected in the post LOCA plant condition. Video to be provided.

RAI Q 28.

Based on discussions with the licensee and PCI in January and February 2008, the NRC staff understood that the test debris was not categorized into specific subgroups of fines and small pieces. Based on a rough visual inspection, the licensee estimated that 30 percent of the small pieces of fibrous debris added to the test were fines. However, the staff does not consider the licensee's estimate to be sufficient because (1) visual estimation of the relative quantities of fine and small piece debris in a given sample is inherently inaccurate and subjective, and would be expected to vary significantly from sample to sample and (2) the high concentration of debris in the prepared debris slurries resulted in significant debris agglomeration, which likely prevented the fines from transporting prototypically in the test flume in any case. As a result, the NRC staff questions whether the licensee's head loss testing resulted in debris settling under debris preparation conditions that are not prototypical of the limiting plant condition. Please provide any information in addition to the information already discussed with the staff that could demonstrate the adequacy of the transport behavior of the fine debris added to the head loss test.

RAI #29

- Drainage sources from Containment Spray near the sump strainers enters as the form of droplets
  - Two spray drainage sources identified near the sump strainers are overhead grating and stairway grating
- Spray drainage would fall as discrete droplets conservatively assuming that their terminal fall velocity is achieved prior to impacting the pool surface

$$KE = \frac{mV^2}{2} = \left(\frac{0.00025}{32.2}\right)\left(\frac{1}{2}\right)(29^2) = 0.0034\ ft-lb$$

- Only a small portion of this kinetic energy will contribute to mixing below the surface, an order of magnitude less than 10% of the kinetic energy.

RAI Q 29.

Please discuss any sources of drainage that enter the containment pool near the containment sump strainers (i.e., within the range of distances modeled in the head loss test flume). Please identify whether the drainage would occur in a dispersed form (e.g., droplets) or a concentrated form (e.g., streams of water running off of surfaces). Please discuss how these sources of drainage are modeled in the test flume. Please provide contour plots of the calculated turbulence (which include a numerical scale with units) for the CFD calculation for the test flume with that for the full-containment plant CFD calculation. Please address whether the test flume turbulence values are prototypical of the plant condition.

RAI #30

- WC/CNP reasonably and conservatively applied the NUREG/CR-6916 test data
  - NUREG/CR-6916 contains a large amount of data on the settling and tumbling velocity of various types and sizes of paint chips. However, the coating thicknesses, densities, and chip sizes for plant specific paint chips vary and typically do not precisely match the chips that were tested.
  - To determine appropriate settling and tumbling velocities for plant specific chips, the test data was compared using a calculated normalization parameter based on the chip thickness, length, and density:

    $X = L \cdot t \cdot (\rho_{chip} - \rho_{l})$
  - A plot of the settling velocity versus the normalization parameter showed a logarithmic trend.
  - A plot of the tumbling velocity for flat chips versus the normalization parameter did not reveal any clear trend.
  - The forces that would act on a flat chip that is resting on the floor were considered (weight, buoyancy, drag, and friction). Since the only variables that are unknown are the drag and friction coefficients for plant specific chips, the ratio of the drag coefficient to the friction coefficient was plotted versus the normalization parameter and found to have a power curve trend.
  - A plot of the tumbling velocity for curled chips versus the normalization parameter showed a linear trend.
  - Using the correlations determined from these trends, the settling and tumbling velocities for the plant specific chips with varying densities, thicknesses, and sizes was determined.
- Paint chips were included in testing.
- Paint chip sizes used in testing were 0.125" to 0.25"

RAI Q 30.

The supplemental response indicates that a correlation for determining the tumbling velocity for paint chips was developed based on NUREG/CR-6916, "Hydraulic Transport of Coating Debris," dated October 2006, data. Please describe the correlation and its application to the WCGS strainer analysis. Please further identify whether paint chips were included in the head loss tests conducted for WCGS. If paint chips were included, then please describe the size distribution of the chips used for head loss testing.

RAI #31

- The Loop A access way is six (6) feet wide, while the Loop D access way is 3 feet wide. The access openings are at the 2001' 4" elevation, one foot four inches above containment floor elevation. The top of the barriers are at elevation 2005'.
- The Loop A barrier is 6' wide by 3' 8" high, for a total surface area of 22.02 ft2 (19.86 ft2 for Callaway). The Loop D barrier is 3' wide by 3' 8" high, for a total surface area of 11.01 ft2 (10.22 ft2 for Callaway).
- As stated above, the top of the barriers is at elevation 2005'. The highest calculated flood level from a LOCA is at 2004' 5".
- The loop barriers are designed for a 12" water level difference between the Reactor side and the Sump side.
- The perforated plate used for the loop barriers has 1/8" diameter holes

RAI Q 31.

Please provide a description of the debris transport barriers installed in the secondary shield wall exits for Compartments A and D, including the following information:

a. the total surface area of these barriers

b. their height compared to the maximum containment pool water level

c. their design differential pressure

d. their perforation size (on page 36 of the December 22, 2008, supplemental response, the perforated openings are stated to be 1/8 inch; however, page 72 appears to imply they are 0.045 inch)

RAI #32

- For a single train case, more smaller, finer (and easily transportable) debris was placed in the test flume
  - For WC: Small fines~198 ft^3 for single vs ~103ft^3 for two train
  - For CNP: Small fines~97 ft^3 for single vs ~51ft^3 for two train
- For the two train case, a higher amount of large (less transportable) debris would have been placed in the test flume
  - For WC: Intact larges ~8ft^3 for single vs 56ft^3 for two train
  - For CNP: Intact larges ~4ft^3 for single vs 28ft^3 for two train
- Therefore, for the single train case, a significantly greater amount of fine debris was placed in the flume and was able to reach the screen and contribute to the tested head loss. This more than offsets the impact of the higher local sump approach velocities for the two train case which may result in greater transport of the large debris.

RAI Q 32.

Please provide the basis for considering the single-train test for Loop D to be bounding. The amount of debris settling in the head loss flume is an unknown variable. Depending on the extent of debris settling in the test flume, a more limiting condition could potentially have resulted from doubling the velocity in the test flume and dividing the debris between two strainers.

RAI #33

- The amount of individual fibers in the small fines mixture was determined by measuring a sample – see RAI #17
- The video the Alden test implemented August 18, 2009 has confirmed separation of fibers upon introduction did occur in a representative and conservative manner as is expected in the post LOCA plant condition.
- For subsequent head loss testing, the graph requested for RAI #40 show the significant jump in head loss, which indicated transport after the introduction of small fines mixture.
- Similar graph available for Callaway.

RAI Q 33.

The thin bed test described in the supplemental response dated December 22, 2008, was actually a fiber-only test. This test was used to observe the transport of fibrous debris without particulate debris clouding the water. The supplemental response stated that the fibrous debris did not clump and moved gently downstream from the introduction point where most of it settled on the flume floor. The licensee concluded that the observations verified that fibrous fines contained as part of the smalls were free to transport and were not captured by the small fibrous pieces. The observations appear to have been qualitative. If the fines added with the smalls are to be credited as fines, the please provide quantitative evidence that fine fibers credited as fines were not entangled in the larger debris pieces. Please state and justify how much of the small debris transported separately and actually behaved as fines. This issue is important in the determination of the amount of fine fibrous debris added to the head loss test. The addition of less transportable debris prior to or at the same time as more easily transportable debris is not consistent with the understanding that the staff reached with PCI/AREVA NP (NRC February 20,2008, memorandum, "Summary of Phone Calls with Performance Contracting, Inc. (PCI)/AREVA/Alden to Discuss Head Loss Test Protocol," ADAMS Accession No. ML080310263) on head loss testing procedures.

RAI #34

Plant	Fibrous Debris Quantity, ft^3			
	Latent	Fines (individual fibers)	Total from DG/DT	Tested Quantities
Wolf Creek Test 3B	6.9	12.7	21.6	21.6
Callaway Test 3C	8.9	6.2	15.1	15.1

- Refer to RAI #17 for amount of individual fibers in small fines mixture
- Refer to RAI #22 for video on how individual fibers separate from small fines mixture on introduction
- Graph on RAI #40 shows the significant jump in head loss after the introduction of small fines mixture

RAI Q 34.

Please provide the amount of fine fibrous debris predicted to be generated and transported to the strainer, including erosion and considering the reduced ZOI credited for debris generation. Please also provide information that verifies that the properly scaled amount of fine fibers was added to the test in a manner that did not inhibit their transport.

RAI #35

- The amount of individual fibers in the small fines mixture was determined by measuring a sample – see RAI #17
- The video the Alden test implemented August 18, 2009 has confirmed separation of individual fibers upon introduction of small fines mixture did occur in a representative and conservative manner, as is expected in the post LOCA plant condition.

RAI Q 35.

Please provide information that justifies that the agglomeration of the fine fibrous debris, observed during head loss testing, did not adversely affect the transport of the debris to the strainer.

RAI #36

- The amount of latent debris added prior to the pump start was a small amount (0.5 lb of the 2.246 lb of latent fiber)
- The video the Alden test implemented August 18, 2009 has confirmed the transportability of the latent fibers introduced 5 minutes prior to pump start up. This test used the same flow velocities as were implemented in the large flume test.

RAI Q 36.

Please provide information that justifies that the addition of debris to the test flume without the recirculation pump running is realistic or conservative or prototypical with respect to the plant condition.

RAI #37

- The determination of whether or not there would be sufficient fibrous debris accumulation to form a fibrous debris bed capable of effectively filtering particulate was based on a single fiber- only test
  - No particulates or chemical effects precipitates were added in this test.
  - After all the fibrous debris was introduced, followed by a minimum of 5 pool turnovers, it was determined from the underwater camera visualization that there was not sufficient fiber on the strainer for effective particle filtration to occur and the test was terminated.
  - The introduction sequence did not affect the test results, since subsequent head loss testing shows a significant jump in head loss when the small fines mixture was added. Refer to RAI #40.
  - The introduction of segregated "fines" before other fiber debris forms and onto the surface of the water column further increases the conservatism of transportation during large flume head loss tests, compared to the prototypical entrainment during recirculation flow.

RAI Q 37.

Please provide information that justifies that the debris addition sequence was conservative or prototypical and that it resulted in a valid thin bed test being conducted. A review of the debris addition sequence described in the supplemental response dated December 22, 2008, indicates that some less transportable debris may have been added prior to more transportable debris. Also, the design basis test appears to use a stratified addition sequence (page 60). First, part of the latent fiber is added (with the pump stopped), then some of the coating particulate, then fines (from erosion and latent fines), then coating chips, then latent particulate and Thermolag, then coating chips, and then small Nukon fibers (including 30 percent fines), followed by miscellaneous debris and other fibers. This is contrary to the guidance in "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing," dated March 2008 (ADAMS Accession No. ML080230038), that states that all particulate should be added prior to the addition of fibrous debris for thin bed testing.

RAI #38

- Calculated CSHL = 0.651 ft at 140°F
  - 0.271 attributable to correlation of core tube
  - 0.380 attributable to standard calculation for plenum
  - CSHL calculation was performed in accordance with PCI white paper sent to the NRC by PCI, letter dated March 25, 2009

RAI Q 38.

Please provide the clean strainer head loss (CSHL), including a breakdown of the portion attributable to the correlation (core tube) and the portion attributable to the standard calculation (plenum). The CSHL should be provided for the lowest temperature case for conservatism.

RAI #39

- Exponential curve fit does not assume any particular bed thickness or morphology.
- The fit matches the form of the measured head-loss data well.
- There was a lack of clarity in the definition of the fit coefficient C_1. Only in Eq. 2 of the supplemental response does C_1 represent the clean strainer head loss. The clean strainer head loss is not calculated as part of the data fitting effort. The supplemental response will be corrected.
- The head loss data point distribution around the mean fit is as expected considering the data has a natural random distribution.
- The fact that virtually all data is bounded by the 95% (±2.5%) confidence interval fits indicates that no portion of the curve is not representative of the data.
- The quality of the fit obtained with the exponential form is superior (statistical reasons) to other forms such as for example a linear fit. The exponential fit best represents the data.
- The extrapolation process employed for the 30 day head loss value is correct.

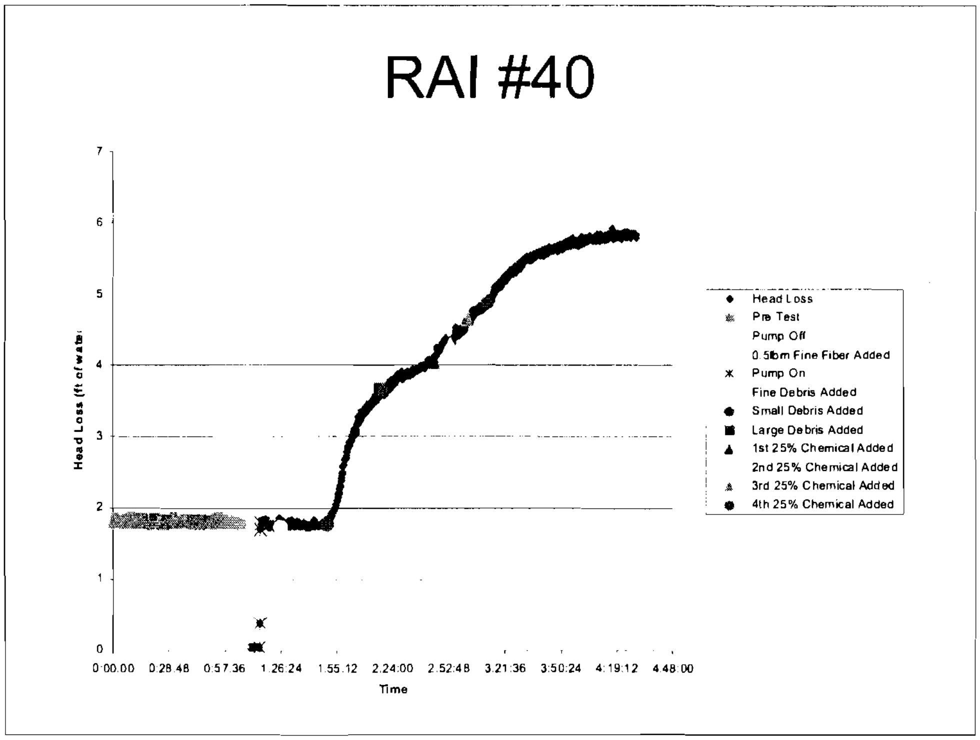
RAI Q 39.

Please provide information that justifies that the extrapolation of head loss results provided a realistic or conservative head loss prediction for the end of the mission time. Alternately, re-perform the extrapolation in a conservative manner consistent with NRC staff guidance referenced in RAI# 27 and provide an explanation that is consistent with the methodology. Please provide adequate data to demonstrate that a suitable time frame was considered during the extrapolation. Please address the following points in your response:

a. The supplemental response describes an exponential function for extrapolation of the final test head loss value to the strainer mission time. The submittal states that the debris head loss is proportional to the average debris bed thickness at a given moment in time. Apparently this assumption is part of the basis for the extrapolation of the test data. Please justify this assumption, which the staff does not believe to be correct. The head loss may have a relationship to debris bed thickness, but there are other variables that may have a larger affect on head loss; for example, debris bed morphology and compaction.

b. The supplemental response provides a relationship for extrapolation of the head loss to the mission time. The constant C1 is stated to be the clean strainer head loss. However, in the examples provided, the constant C1 represents the maximum head loss attained during the test.

c. The examples and extrapolation curves provided do not appear to correspond to the description of the relationship. The curve fit drawn on the data plot does not appear to actually fit the data or to be conservative. It appears that an exponential function was assumed and made to fit the data as well as possible. However, multiple data points taken during the first day of the test exceed the final, 30-day extrapolated head loss. This is clearly non-conservative.



RAI Q 40.

Please provide a plot of the head loss test data from the initiation of the test to the end of the test with significant test evolutions annotated on the plot.

RAI #41

- SBLOCA water level would cover top of core tube by minimum of 8 inches
- SBLOCA reduced flow rates through strainer
  - Max of 1500 gpm
- Refer to RAI #2 response (SBLOCA water level - submergence)

RAI Q 41.

Please verify that the core tube is fully flooded under all conditions for which recirculation is required, or re-evaluate the potential for vortex formation. If testing is credited, details of the test conditions should be provided. It should be noted that, if the core tube has air in it, a vortex may not be observed on the surface of the test tank and that some other measurement of air entrainment would have to be employed. On page 48, of the supplemental response dated December 22, 2008, stated that the SBLOCA case will result in 2.5 inches of the strainer stack top module being exposed. On page 47, the licensee stated that the SBLOCA may result in a water level less than approximately 6 inches below the top of the strainer at switchover. Please verify which statement is accurate. In addition, please verify that the accumulators will discharge to add to the sump liquid inventory under all LOCA conditions. If the accumulators do not discharge for all LOCAs, please evaluate strainer submergence, and potential for vortex formation and air entrainment, at alternate sump level conditions that do not assume accumulator discharge.

RAI #42

- A minimal amount of containment pressure is necessary for flashing to not occur.
- WC/CNP will submit information similar to that submitted by ANO.

RAI Q 42.

Because no containment accident pressure was applied during the evaluation and the sump temperature can reach 212 of, the supplemental response dated December 22, 2008, stated that boiling and flashing could occur across the strainer debris bed. The supplemental response concluded that any voids would re-condense in the interior of the strainer modules before leaving the strainer assembly and entering the suction piping of the containment spray/emergency core cooling system pumps. Because the strainers are relatively tall vertical stacks in a sump pit this is likely true. However, the supplemental response did not discuss the potential affect of voiding on the head loss across the debris bed and how changing the head loss could lead to additional voiding. Please provide information regarding the amount of accident pressure required to prevent voiding within the debris bed and strainer and verify that the required containment pressure is available at the required times during the postulated event to prevent flashing. Please provide the minimum margin to flashing. In addition, please provide an evaluation of gas evolution downstream of the strainer that could reach the pump suction. Please provide the percentage of evolved gas estimated at the pump inlet.

RAI #43

- The methodology for extrapolating and temperature scaling of the WCGS and CNP head loss test results is based on viscosity ratios for temperatures. See section 3f.13 of ML080700356.
- The total strainer head loss is based on the debris laden head loss and the clean strainer head loss components, as shown on next page.
- The NPSHa analysis is based on 212F and is not time or temperature dependent.

RAI Q 43.

Please provide the head loss value that was used as the basis for the value extrapolated to alternate fluid temperatures including any extrapolation to the mission time and the temperature at which the head loss was measured. Please provide the temperature corrected head loss including the conditions to which it is corrected. Please provide the methodology for extrapolation and temperature scaling of the head loss. For example, please state whether the test clean strainer head loss was subtracted from the measured value prior to extrapolation and/or temperature correction. Please explain how the calculated clean strainer head loss was combined with the final debris head loss to determine the final overall head loss. If the net positive suction head (NPSH) analysis is time-or temperature-dependent, please provide details as to how the debris and strainer head loss was calculated for the evaluated conditions.

RAI #43 (cont'd)

Calculated or Tested Head Loss	Sure-Flow® Suction Strainer Head Loss Component	Head Loss Determination Methodology	Temperature Correction Methodology	Comment
Calculated head loss values	SFS Module CSHL	PCI 'Regression Formula'	Kinematic viscosity used within formula for temperature correction	Establishes CSHL of Sure-Flow® Suction Strainer modules
	SFS 'Non-Module' Connecting Piping and Fittings, or Collection Plenum	Conventional hydraulic calculation applications and methodology	Moody Diagram as appropriate - not temperature corrected	Establishes CSHL of Sure-Flow® Suction Strainer Non-Module piping & fittings, or collection plenum
Head loss values from testing	ARL SFS Module CSHL	Actual Sure-Flow® Suction Strainer module test results	Kinematic viscosity of water used for correction from test to Design Basis temperature	Establishes CSHL of Sure-Flow® Suction Strainer modules based on actual testing
	ARL SFS Debris Laden Head Loss	Actual Sure-Flow® Suction Strainer module debris laden test results	Dynamic (absolute) viscosity of water used for correction from test to Design Basis temperature	Establishes TSHL of Sure-Flow® Suction Strainer modules based on actual testing

RAI Q 43.

Please provide the head loss value that was used as the basis for the value extrapolated to alternate fluid temperatures including any extrapolation to the mission time and the temperature at which the head loss was measured. Please provide the temperature corrected head loss including the conditions to which it is corrected. Please provide the methodology for extrapolation and temperature scaling of the head loss. For example, please state whether the test clean strainer head loss was subtracted from the measured value prior to extrapolation and/or temperature correction. Please explain how the calculated clean strainer head loss was combined with the final debris head loss to determine the final overall head loss. If the net positive suction head (NPSH) analysis is time-or temperature-dependent, please provide details as to how the debris and strainer head loss was calculated for the evaluated conditions.

RAI #44

- A more accurate description of the water volume required to fill the RCS steam space is the volume of the pressurizer steam space, which is to maintain pressure control during normal plant operations. This volume would not be available to the containment water level upon an RCS line break.
- There is not a discrepancy in the stated values for containment water level.

RAI Q 44.

Page 81 of the December 22,2008, supplemental response indicates that a water volume required to fill the RCS steam space is accounted for as a hold-up volume not contributing to the containment building water level. However, page 83 of the same document indicates that an approximate volume of 8900 cubic feet (ft3) from the 12,135 ft3 inventory of the RCS is credited in the containment water level calculation at switchover. Please clarify this apparent discrepancy, as it pertains to both the calculated large-break and small-break post-LOCA containment water levels.

RAI #45

- The Keeler and Long report section 8.0 shows larger chips in the autoclave basket. These samples were removed and categorized for TXU. The results are described in ALION-REP-TXU-4464-02, “TXU Paint Chip Characterization,” October 2007 (ADAMS Accession No. ML081770357).

RAI Q 45.

For degraded qualified coatings, the Keeler and Long report, "Design Basis Accident Testing of Coating Samples from Unit 1 Containment, TXU Comanche Peak SES," dated April 13, 2006 (ADAMS Accession No. ML070230390), and industry testing are cited by the licensee as justification of epoxy chip sizes. While the NRC review guidance has accepted use of the Keeler and Long report as justification for degraded qualified epoxy coatings failing as chips, the resulting chip sizes from the Keeler and Long report are smaller than those described in table 3h-2 of the submittal dated December 22, 2008. Please provide justification for using chips larger than those determined in the Keeler and Long report. In addition, please supply the industry testing reference used on page 87 of 128 of the December 22, 2008, supplemental letter, to determine the size distribution of degraded qualified coatings.

RAI #46

- The quantity of curled chips was determined by examining each and every chip provided from the Keeler and Long autoclave testing. See Section 8.0 of the report.
  - The coatings from each autoclave section were separated out by size characterization.
  - Each chip was characterized if it was flat or curled, and the length of each chip at it's longest apex was recorded.
  - The chips were then sorted by those that were greater than 1" in length, those that were ½ to 1", ¼ to ½", 1/8th to ¼" and then below 1/8th".
- The number of curled chips in each category was determined and the percentage of curled chips by category was recorded.
- This information can be found in ALION-REP-TXU-4464-02, "TXU Paint Chip Characterization," October 2007 (ADAMS Accession No. ML081770357).

RAI Q 46.

Please describe how the quantity of curled chips was determined. In addition, please justify the simplification of the size distribution of the curled chips to a 1.5-inch chip size.

RAI #47

- This RAI on in-vessel downstream effects will be addressed 90 days following the issuance of the final NRC staff SE on WCAP-16793.

RAI Q 47.

The NRC staff does not consider in-vessel downstream effects to be fully addressed at WCGS, as well as at other pressurized-water reactors (PWRs). WCGS's submittal refers to draft WCAP-16793-NP, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous, and Chemical Debris in the Recirculating Fluid." The NRC staff has not issued a final SE for WCAP-16793-NP. The licensee may demonstrate that in-vessel downstream effects issues are resolved for WCGS by showing that the licensee's plant conditions are bounded by the final WCAP-16793-NP and the corresponding final NRC staff SE, and by addressing the conditions and limitations in the final SE. The licensee may also resolve this item by demonstrating without reference to WCAP-16793 or the NRC staff SE that in-vessel downstream effects have been addressed at WCGS. Please report how the in-vessel downstream effects issue has been addressed for WCGS within 90 days of issuance of the final NRC staff SE on WCAP-16793.

RAI #48

AlOOH 1-Hour Settling Test

Test	Date	Acceptance Criteria	Results (after 1 hour)	PH of Solution
3B	1/17/2008	>9mL	9.3mL	9.84
3C	1/21/2008	>9mL	9.4mL	10.23

RAI Q 48.

The caption for Figure 30-1 on page 120 in the December 22,2008, supplemental response appears to imply that this figure provides the results of settling tests for the aluminum oxyhydroxide (AlOOH) used in head loss testing for WCGS. This figure is identical to Figure 7.6-1 of WCAP-16530-NP-A, which is not plant-specific. Please provide the 1-hour settlement values for all batches of AlOOH used in head loss testing for WCGS.

RAI #49

- Min-K is encapsulated and therefore, protected from containment spray
- The fire barrier material, Darmat KM-1, installed in Containment is outside of the secondary shield walls and most of it (780 of the 792 inches) is under an overhead concrete floor slab; thereby protecting the fire barrier material from the containment spray flow path.
- The fire barrier material meets the requirements of the ASTM E-119 hose stream test. The following information from the test report for 3-hour fire test on Darmatt KM1 supports the conclusion that there is no concern of leaching from containment spray flow, as the protective cover remains intact.
  - Nozzle pressure - 75 psi,
  - Distance of the nozzle from the sample - 5 feet,
  - Discharge flow rate - 75 gpm.
- Both above flood plain

RAI Q 49.

The licensee did not consider Min-K and Darmat KM1 as part of the debris generated based on where they are located in the containment and that they are outside the ZOI for destruction. Please state and justify whether either of these materials is sUbject to wetting by containment spray. If so, please state and justify whether the leached ionic material from these insulations been included in the inventory of chemicals found in the containment sump liquid following the spray phase of the LOCA for input to head loss testing.

RAI #50

- All of the generated NUKON debris for the bounding break was considered in the leaching amounts in Table 3o-1.
- A margin was considered in the chemical effects calc for leaching of other materials.
- Cerablanket is only located in the reactor cavity. This insulation is not affected by a LOCA, except for the LOCA in the reactor cavity. The Cerablanket located in the reactor cavity is not in the Containment Spray flow path and therefore not subject to leaching and then being washed to the recirculation sumps, for any LOCA other than LOCA in the reactor cavity.
- LOCA in the reactor cavity is not bounding for chemical effects.

RAI Q 50.

Table 3o-1 on page 120 in the December 22,2008, supplemental response, identifies the amounts of precipitate formed from various components in containment. Although the NUKON fabric coating prevented loss of the insulation fibers, please state and justify whether the material leached from the NUKON during the spray and recirculation phase was accounted for in the concentration of ionic materials in the containment sump. Please state whether the mass of aluminum in the sodium aluminum silicate calculated for the Reactor Cavity column includes dissolved aluminum from all the Cerablanket that would be wetted in containment. If not, please discuss why the aluminum in wetted Cerablanket outside the reactor cavity does not contribute to chemical effects.

ENCLOSURE 3

CALLAWAY AND WOLF CREEK RAI CROSS-REFERENCE MATRIX

PROVIDED BY CALLAWAY VIA E-MAIL ON JULY 17, 2009

AUGUST 27, 2009, PUBLIC MEETING WITH

UNION ELECTRIC COMPANY AND

WOLF CREEK NUCLEAR OPERATING CORPORATION

Comparison of Callaway RAIs (dated November 2008) to WCNOC RAIs (dated July 2009)

RAI #	Question	WC question(s)
1	Please provide information that verifies that the break selection process was completed considering the reduced zones of influence (ZOIs) based on WCAP-16710-P, or that the originally selected breaks remain bounding from a debris generation perspective after reducing the ZOIs for Min-K and jacketed Nukon.	1
2	Please explain whether secondary breaks (main steam or feedwater) could require recirculation to supply containment spray. If one or more secondary breaks require recirculation for containment spray, provide information that shows whether the analysis for any loss-of-coolant accident (LOCA) bounds the secondary break(s). If secondary breaks are not bounded by LOCA analyses, please address the impact of such breaks on ECCS strainer performance, including the method used to determine the limiting MSLB location.	None
3	Considering that the Callaway debris generation analysis diverged from the approved guidance in NEI 04-07, please provide details on the testing conducted that justified the ZOI reductions for encapsulated Min-K and the jacketed Nukon. The information should include the jacket materials used in the testing, geometries and sizes of the targets and jet nozzle, and materials used for jackets installed in the plant. Provide information that compares the mechanical configuration and sizes of the test targets and jets, and the potential targets and two-phase jets in the plant. Evaluate how any differences in jet/target sizing and jet impingement angle affect the ability of potentially impacted insulation to resist damage from jet impingement. State whether the testing in WCAP-16710-P was bounding for the Callaway insulation systems. If not, provide information that compares the Callaway encapsulation and jacketing systems structure with the system that was	4
4	The supplemental response showed that the Callaway debris generation/ZOI analysis contained three size categories of fibrous insulation debris: small fines, large pieces and intact. However, as stated in the staff's safety evaluation on NEI 04-07, in order to conduct adequate transport analysis and head loss testing, the small fines should be further broken down into fines (suspended fibers) and small pieces (less than four inches on a side). Using this categorization system (or justifying a different categorization), please provide additional information on the amounts of fibrous debris predicted to be generated from various breaks.	16/17
5	The supplemental response (pg 12 of 81) stated that the Min-K at Callaway is located near the reactor vessel. This raises the question as to whether spherical resizing was done and whether it is appropriate for this location. The staff's audit report for San Onofre discusses a potentially similar issue (Open Item 1 in Section 3.2, ADAMS Accession No. ML071240024) regarding Microtherm insulation that was located on the reactor vessel, for which spherical resizing was considered inappropriate by the staff due to the constraints imposed by the biological shield wall and reactor vessel. Please state whether a spherical ZOI was assumed in this region for which substantial physical obstructions could result in a significantly non-spherical destruction zone, and, if applicable, provide a	15
6	The WCAP-16710-P ZOI reduction for jacketed Nukon insulation was also taken for Thermal Wrap at Callaway. Please provide information on the jacketing, banding and/or latching, and cloth cover for the Thermal Wrap insulation to provide confidence that it is comparable to the jacketing system for the Nukon	14
7	The staff has concerns that the size of the nozzle being used for the NUKON destruction testing at Wyle Laboratories may have resulted in non-conservatively exposing only a limited area of the target material to the peak jet pressure, particularly for the tests conducted at the smaller ZOI radii. Since a LOCA jet could be much larger than 3 inches in diameter, the testing may not be representative of an actual LOCA at close ranges where the pressures of the smaller-diameter jet used for the testing would decay significantly more rapidly in the radial direction. This potential non-prototypicality from the debris generation testing affects not only the determination of ZOI size, but also the determination of the size distribution of the debris formed within that ZOI. Appendix II to the safety evaluation on NEI 04-07 indicates that essentially all low-density fiberglass within 7 pipe diameters (7D) of a pipe rupture would become small fines. However, based on the	16
8	The staff's safety evaluation (SE) for NEI 04-07 stated that a maximum of 15% holdup of debris should be assumed in inactive holdup regions during pool fill up. For the case of single-train sump operation for Callaway, a two-sump plant, the sump that is not operating essentially becomes an inactive holdup region. From this point of view, the staff observed that Callaway appeared to credit a 15% inactive holdup volume in the containment pool, plus 14% holdup in the inactive recirculation sump for single-train cases, for a total of 29% of debris held up in inactive volumes for these single-train cases (e.g., the Loop D cross-over break). The staff considers this credit a deviation from the approved guidance in the SE, which stated that the limit for inactive hold up should be 15% unless a computational fluid dynamics (CFD) analysis was performed that considered the time-dependent containment pool flows during pool fill up. Please provide	19
9	The supplemental response discusses Stokes' Law, but does not specifically quantify the credit taken for application of this methodology. Please state the quantities of fine debris assumed to settle onto the containment floor by applying the Stokes' Law methodology. If credit is taken for such settling, technical justification is needed regarding the following points: (1) (lack of) experimental benchmarking of analytically derived TKE (turbulent kinetic energy) metrics; (2) uncertainties in the predictive capabilities of TKE models in CFD codes, particularly at the low TKE levels necessary to suspend individual fibers and 10-micron particulate; (3) the basis for analytical prediction of settling velocities in quiescent water due to the specification of shape factors and drag coefficients for irregularly shaped debris; and (4) the basis for theoretical correlation of the terminal settling velocity to turbulent kinetic energy that underlies the Alion	20
10	Please identify the source of the erosion testing used to justify 10% erosion of fiberglass in the containment pool for Callaway and specify the velocity, turbulence and chemical conditions for which the testing is applicable, and the velocity, turbulence and chemical conditions present in the Callaway containment pool.	21
11	The licensee's submittal indicated that their analyses and/or testing were substantially incomplete in the head loss and vortexing area. The staff will review the remaining information when the licensee submits it, and as a result of such review the staff could request additional information in this subject area. Among items that should be addressed are:	

Comparison of Callaway RAIs (dated November 2008) to WCNOC RAIs (dated July 2009)

11a	At the beginning of recirculation for a small-break LOCA, the strainer stacks are not submerged by about six inches. This condition should be evaluated for vortexing, air ingestion, and failure of the strainer to pass adequate flow.	41
11b	The PCI clean strainer head loss calculation is founded on a correlation based on prototype BWR strainer testing. The BWR strainers have a significantly different geometry than PWR strainers. The staff has stated that the applicability of the BWR prototype correlation to PWR strainers has not been shown to be	38
11c	c. The Callaway strainer testing was witnessed by the staff. The staff observed that significant agglomeration of debris occurred during testing. The staff also noted that the amount of fine debris predicted to reach the strainer was extremely low compared to other plant evaluations that used test methods the staff has found to be generally acceptable. Because the testing was designed to credit near-field settling, these issues could have significantly affected the results of the testing in a non-conservative manner. It was noted in the debris characteristics section of the supplemental response that the small debris contained about 30% fines. However, if the fines were not separated from the smalls prior to addition, it is likely that they would become entangled or agglomerated with the larger debris. This would reduce fine debris transport and the ability of the fibrous debris to create a thin bed. In fact, in PCI testing witnessed by the staff after the	33/35
11d	d. The supplemental response states that no containment accident pressure is credited with regard to head loss, vortexing, air ingestion, or void fraction determination. Considering the small strainer submergence for a large-break LOCA (relative to the head loss across the strainer screen) and lack of submergence for a small-break LOCA, it is not clear to the staff what pressure prevents flashing across the debris bed and strainer.	42
12	The licensee's submittal indicated that its analyses and/or testing were substantially incomplete in the net positive suction head (NPSH) area. The staff will review the remaining information when the licensee submits it, and as a result of such review the staff could request additional information in this subject area. Among items that should be addressed are:	None
12a	the completed NPSH analyses with the quantitative results for the NPSH margins,	None
12b	both cold-leg and hot-leg recirculation scenario NPSH margins for all pumps taking suction from the recirculation sump,	None
12c	the NPSH margin values for the small- and large-break LOCAs	None
12d	the pump vendor's criteria for determining the NPSH required (NPSHr) data for the pumps taking suction from the recirculation sump,	None
12e	the specific methodology used for computing friction head loss in suction piping, and	None
12f	a summary of the single failure analysis for the NPSH calculation (single failure scenarios considered should be identified, and NPSH margin results should be	None
13	For degraded qualified coatings, the Keeler and Long Report and industry testing are cited as justification of epoxy chip sizes. The NRC Revised Content Guide has accepted use of the Keeler and Long Report, which results in smaller chip sizes than those described in table 3h-2. Please provide justification for using chips larger than those determined in the Keeler and Long report. In addition, please summarize methods and results of the industry testing reference used to determine the size distribution of degraded qualified coatings.	45
14	Please describe how the quantity of curled chips is determined. In addition, please justify the simplification of the size distribution of the curled chips to a 1.5 inch	46
15	Please clarify the weight distribution of coating debris surrogates used in head loss testing. Please explain whether it is consistent with table 3h-2 in the submittal. If so, please explain the basis for the distribution in table 3h-2.	None
16	Please provide the quantities of each type of coatings surrogate material used in head loss testing.	None
17	The licensee's submittal indicated that its analyses and/or testing were substantially incomplete in the downstream effects, components and systems, fuel and vessel area. The staff will review the remaining information when the licensee submits it, and as a result of such review the staff could request additional information in this subject area. When submitted, please provide the information requested under item (n) in the Revised Content Guide for Generic Letter 2004-02 Supplemental Response dated November 2007. The NRC staff considers in-vessel downstream effects to be not fully addressed at Callaway as well as at other PWRs. The Callaway GL 2004-02 submittal refers to draft WCAP-16793-NP, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous, and Chemical Debris in the Recirculating Fluid." The NRC staff has not issued a final safety evaluation (SE) for WCAP-16793-NP. The licensee may demonstrate that in-vessel downstream effects issues are resolved for Callaway by showing that the licensee's plant conditions are bounded by the final WCAP-16793-NP and the corresponding final NRC staff SE, and by addressing the conditions and limitations in the final SE. The licensee may also resolve this item by demonstra	47
18	Please provide the basis that demonstrates that chemicals leaching from insulations and other containment materials that are sprayed but not submerged (i.e., located above the flood plane following a LOCA) are not significant to chemical precipitate formation.	None
19	Please identify and justify the assumptions related to phosphate inhibition of aluminum corrosion. For example: (1) what is the threshold concentration of phosphate assumed to passivate aluminum? (2) what time is assumed to reach that phosphate concentration in the pool? and (3) if phosphate inhibition is credited for aluminum in the spray zone, what amount of containment spray time is assumed (after the pool reaches an inhibition threshold of phosphate) before	None

Please direct any inquiries to me at (301) 415-3016 or Balwant.Singal@nrc.gov.

Sincerely,

/RA by Mohan C. Thadani for/

Balwant K. Singal, Senior Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-482 and 50-483

Enclosures:
1. List of Attendees
2. Proposed Approach to RAI Responses
3. Callaway and Wolf Creek RAI Cross-reference Matrix

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DATE	9/14/09	9/25/09	9/11/09	9/21/09	9/28/09	9/28/09

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