January 18, 2002

Mr. Alexander Marion
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1776 I Street, NW, Suite 400
Washington, DC 20006-3708

SUBJECT: NRC OFFICE OF NUCLEAR REGULATORY RESEARCH RESPONSES TO COMMENTS PROVIDED ON DRAFT REPORT, "GSI-191: PARAMETRIC EVALUATIONS FOR PRESSURIZED WATER REACTOR RECIRCULATION SUMP PERFORMANCE"

Dear Mr. Marion:

In a letter dated August 31, 2001, NEI provided comments on the subject draft report prepared by Los Alamos National Laboratory (LANL) under contract to the NRC. In Table 1 attached to your letter, you provided a list of specific comments regarding the draft report. We also received several comments during the public meeting held on July 26 and 27, 2001. Our responses to each of these comments are provided in Enclosure 1.

The NRC Office of Nuclear Regulatory Research (RES) has recently transferred the lead for completing the resolution of GSI-191 to the Office of Nuclear Reactor Regulation (NRR). If you have any questions or comments regarding the RES effort to date in developing the technical assessment for GSI-191, please contact Michael Marshall at (301) 415-5895, e-mail MXM2@NRC.GOV, or if you have questions or comments regarding the NRR effort in developing a final resolution for GSI-191, please contact Rob Elliott at 415-1397, e-mail RBE@NRC.GOV .

Thank you for your comments and for the interest NEI has shown in our sump performance research program. We feel that we have benefitted from your active participation during public meetings we have held to discuss our approach and findings. We look forward to continuing this interaction as we explore resolution paths for GSI-191.

Sincerely,

/RA/

Michael E. Mayfield
Division of Engineering Technology
Office of Nuclear Regulatory Research

Enclosure: As stated
cc: J. Butler, NEI

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Table 1: Responses to NEI Comments Attached to Letter Dated 8/31/2001

1 As discussed at the July 26 and 27 public meeting:

Confirm that the “Zone Of Influence” used to estimate the region of debris generation accounts for physical barriers, such as a crane wall or refueling canal, for the sixty-nine (69) cases evaluated in the draft report.

Identify if any cases have been reevaluated so as to account for these physical barriers, and if so, the impact on the conclusions drawn for these cases.

RESPONSE:

The type and location of debris sources are an important factor in determining whether debris accumulation on sump screens will result in loss of NPSH margin. During the public meeting it was stated that the zone of influence does not account for physical barriers nor does it account for the exact location of debris sources. None of the cases have been reevaluated to account for physical barriers. Physical barriers may reduce the amount of debris generated by some LLOCAs. For large and medium LOCAs, the debris generated by small LOCAs provides meaningful insights into how a reduction of the amount of debris generated may Affect the possibility of debris accumulation on sump screens leading to loss of NPSH margin.

The parametric evaluation methodology can be divided into two parts. The first part is estimating the amount of debris needed to cause loss of NPSH margin (i.e., a minimum debris threshold). The second part is estimating the amount of debris expected to reach the sump screen using favorable and unfavorable assumptions. Many of the cases had very small minimum debris thresholds (i.e., $\leq 2ft^3$), which are not dependent upon the amount of debris generated or amount of debris transport.

The purpose of the parametric evaluation was to significantly vary key parameters, such as debris amounts and debris accumulation, to examine the results on NPSH margin. The parameters were varied over a very broad range such that their sensitivity on the result could be revealed, since there is significant uncertainty in the estimates of any of the parameters. Reducing the ZOI has the effect of lessening the debris amount parameter, which can have an effect on some of the more favorable cases. However, the evaluation reveals that for many of the cases, the results are Likely (for blockage) and are not highly sensitive to somewhat lesser amounts of debris. To illustrate this point, all the parametric cases were re-evaluated assuming that the LLOCA debris quantity was the 50th percentile value versus the 95th percentile value, which represent a significant decrease in debris. The use of the 50th percentile resulted in a modest increase (i.e., 6) in cases being classified as Unlikely. Therefore, the overall conclusion that plant-specific analyses should be performed would not change.

2 The draft report states that “numeric simulations” confirm the selection of ½ the pool height as the “failure criteria” for partially submerged sump screens. Additional information and/or references should be added to the report, which provide the basis for

the chosen failure criteria.

RESPONSE:

The basis for the failure criterion used in the GSI-191 parametric evaluation will be documented in a separate technical report. The technical reports that are being produced to document the work conducted to support the GSI-191 parametric evaluation should be released to the public by the end of February 2002.

3 The study acknowledges that time was not taken into account. The element of time is important, and should be accounted for in considering the timing of the sequence of events attributing to debris generation, transport to the sump and subsequent postulation of sump screen blockage.

RESPONSE:

Many of the time dependent parameters or plant conditions that affect timing vary widely from plant to plant. The GSI-191 parametric evaluation methodology was designed to minimize the need to rely upon time dependent parameters or plant conditions that affect timing. Because of the plant-to-plant variability with regard to the number of time dependent parameters, this comment would be best addressed by plant-specific analyses.

4a The transport fraction for pool transport was determined utilizing observations from the tank tests and the flume tests conducted at the University of New Mexico. If this understanding is correct, appropriate consideration may not have been given to establishing the conditions required for similitude between the tank tests and a representative containment. The quoted test flow rates produced velocities that approximate the velocities expected in plants. However, there are many other significant differences between the tests and plants. These include:

Containment pool vs. tank volume, which Affects volume exchange time and time for transport of debris to the sump screen. The volumetric turnover in the test is about five to seven (5 – 7) times for each turnover expected for a representative plant.

Differences between introduction of water into pools in the test articles (all in one location) versus the plant (break location, overflow from refueling canal, runoff from containment walls and floors). This results in tests having higher local turbulence levels in the pool, which promotes both the suspension of particulates and, possibly, fibrous debris, as well as the transport of those debris to the sump screen.

Increases in turbulence levels in the tests compared to the plants due to the non-linear scaling of turbulence associated with linear scaling between test models and the prototype. The increase in local turbulence levels in the tests, promotes the suspension and transport of both particulates and, possibly, fibrous debris.

Basis for both the amount and the composition (debris make-up; % RMI, % fibrous, etc.) of debris used in the tank tests compared to plants. If the tank test were to be used as a guide for transport fraction, good test practice would suggest that approximately proportionate debris would be introduced into the flow stream for the test as would be expected in the plant.

RESPONSE:

The tank tests do not represent a scale model of a containment floor. In order for credible scaled tests to be conducted that simulated conditions and configuration of an operating PWR, proportionate debris would have to be used. The results from the tank test were never intended to be applied to operating PWRs. The purpose of the tank tests was to demonstrate the feasibility of using data collected from the large flume tests and CFD prediction of flow patterns in containments to predict transport for a range of debris sizes (i.e., fines, shreds, and fluff) for inclusion in a detailed (i.e., similar to plant-specific) analysis. A detailed analysis was not conducted as part of the parametric evaluation.

Some of the tests conducted during the GSI-191 Technical Assessment were intended to support analyses that were not pursued because of changes in technical approach.

A separate technical report is being prepared to describe what tests were conducted to support the GSI-191 parametric evaluation. The technical reports that are being produced to document the work conducted to support the GSI-191 parametric evaluation should be released to the public by the end of February 2002.

4b The fraction of debris transported to the sump by spray washdown was given as 75%. This value may not be representative as the spray nozzles are installed so as to deliver the majority of the spray inventory to the operating deck floor. From there, the fluid is (generally) ducted into the refueling canal where additional settling of particulates and potential entrapment of fibrous debris might occur.

It is recommended that this comment be addressed in the final report.

RESPONSE:

Plant data collected during the sump and containment survey distributed by NEI was augmented with plant specific data from one of the two volunteer plants that participated in the GSI-191. Location of spray nozzles was not a question in the survey, so the volunteer plants were used to ascertain the impact of sprays on transport. Both of the volunteer plants had spray nozzles located below the operating deck.

Depending on the location and operation of sprays at different plants, the fraction of debris transported by spray washdown may vary widely from plant to plant. Also, if debris other than fines were included in the parametric evaluation, the percent of debris transported by washdown may be less, but the total amount of debris may increase. Because of the plant-to-plant variabilities with regard to spray location and operation, this comment would be best addressed by comparing plant-specific analyses.

A separate technical report is being prepared to better explain how debris transport was estimated in the GSI-191 parametric evaluation. The technical reports that are being produced to document the work conducted to support the GSI-191 parametric evaluation should be released to the public by the end of February 2002.

5 The head loss correlation given in NUREG/CR-6224 suggests the use of various physical parameters for each of the constituents of the debris bed, e.g. fiber diameter, particulate diameter, macro and microscopic densities, etc. Neither the report nor the presentation at the July meeting identified the debris characteristics used in calculating the NUREG/CR-6224 head loss correlation. These should be included in the report.

RESPONSE:

The parametric evaluation only considered four types of debris that are common to most PWRs: (1) fiberglass, (2) metal, (3) calcium silicate, and (4) particulates. The fiberglass used to develop and benchmark the NUREG/CR-6224 correlation has the same physical characteristics as the fiberglass commonly found in thermal insulation used in PWRs. The NUREG/CR-6224 correlation produces accurate estimates of head loss associated with fiberglass or combinations of fiberglass and particulates up to 50 ft of H_2O per inch of debris bed thickness. The NUREG/CR-6224 correlation has been shown to significantly under-predict the head loss caused by calcium silicate debris. Use of the NUREG/CR-6224 correlation is appropriate without additional testing for a study intended to demonstrate whether debris accumulation is a problem for PWRs. Use of the correlation for plant-specific analyses that involve debris types (e.g., calcium silicate) that were not part of the development of the correlation may be inappropriate.

6 The methodology of NUREG/CR-6224 uses a high filtration efficiency for fibers. For particulates, the filtration efficiency is proportional to the fiber bed thickness. Significant overestimation of head loss can occur if high filtration efficiency is used for particulates. The filtration efficiency for the different debris used in the head loss calculations should be included in the report.

RESPONSE:

The methodology used in NUREG/CR-6224 does not have a predetermined filtration efficiency. Filtration efficiency is used to estimate the amount of particulate captured by the debris bed. The filtration efficiency of a debris bed varies with time. The efficiency of the debris bed increases as the debris bed thickness increases and porosity decreases. For debris beds greater than 1/8 inch thick, the filtration efficiency is very high (approximately 75%). Typically it is best to conduct tests with the expected proportions of debris to measure variation in filtration efficiency with changes in debris bed thickness. At a point in time, a maximum filtration efficiency will be reached.

Unlike the methodology described in NUREG/CR-6224, the GSI-191 parametric evaluation methodology does not account for time. The parametric evaluation can be divided into two parts. The first part is estimating the amount of debris needed to cause loss of NPSH margin (i.e., a minimum debris threshold). The second part is estimating the maximum amount of fine fibrous and particulate debris expected to reach the sump screen using favorable and unfavorable assumptions. Since the GSI-191 parametric evaluation methodology only considers the maximum amounts of debris estimated to accumulate on the sump screen, this approach is insensitive to filtration efficiency.

The findings of the GSI-191 parametric evaluation are not dependent upon filtration efficiency.

7 Compaction of the debris bed may be a critical factor in determining head loss through the debris bed.

It was not clear from the draft report what was assumed for debris bed compaction in the calculation of head loss across the debris bed.

NUREG/CR-6224 indicates that the head loss correlation may over-predict head loss for thin beds coupled with high particulate-to-fiber mass ratios. Was this over-prediction addressed in the determination of thin bed head loss and if so, a description should be included in the report?

RESPONSE:

High particulate-to-fiber mass ratios typically result in very large head loss that may challenge the integrity of an uniform debris bed. The limit associated with the NUREG/CR-6224 correlation is 50 ft of H_2O per inch of debris bed thickness. Most of the NPSH margins for the cases in the parametric evaluation were less than 5 ft of H_2O which is significantly below the limit.

Because NPSH margins for the majority of cases were very small, high particulate-to-fiber mass ratio has no effect on the GSI-191 parametric evaluation findings.

8 During the public meeting, industry representatives identified several conservative assumptions and approaches used in the draft. The NRC contractor generally acknowledged this with statements that there were one or more orders of magnitude difference between the estimated head loss and allowable margin. This large difference was given as the basis for not evaluating the impact of these conservative assumptions. This was the general response by the contractor. We recommend that the report discuss these conservatisms and the impact to estimated head loss and allowable margin.

RESPONSE:

The impact of all assumptions and conventions used in the GSI-191 parametric evaluation that may change the findings have been considered either qualitatively or quantitatively. Aside from no credit for physical barriers, the assumption of a 95th percentile debris generation quantity, and the use of licensing NPSH margin, which may be considered conservative, there are no other assumptions or conventions that should be characterized as conservative in the parametric evaluation. However, there are a number of assumptions and approaches that could be characterized as non-conservative. Those include:

1. Treating calcium silicate debris as a particulate in the NUREG/CR-6224 correlation. The correlation is known to significantly underpredict the head loss caused by calcium silicate.

2. Ignoring head loss contribution of RMI in debris beds formed with fiberglass, particulates and metal.

3. Using relatively small values (even for "unfavorable" values) for particulate debris.

4. Using fiberglass instead of other fibrous materials (e.g., mineral wool) known to lead to greater head losses.

5. Ignoring all debris types and sizes except fine fiberglass, small mass of particulates, calcium silicate, and metal when estimating amount of debris available for transport.

6. Decreasing the ZOI below the distance observed during testing.

7. Ignoring head loss caused by debris beds thinner than 1/8 or 1/4 inch.

The assumptions referenced in this comment have been addressed in responses to other comments.

9 It is unclear why RCP Seal LOCA was categorized as a particular size of LOCA when other mechanical-failure-induced LOCAs (e.g., stuck/spuriously opened primary relief or safety valve, as listed on Slide #4 of the PRA presentation) were not. The rationale for concluding that a difference exists between debris-generation mechanisms for RCP Seal LOCA and other small LOCAs should be provided.

RESPONSE:

Of the three LOCAs included in the GSI-191 parametric evaluation, the RCP seal LOCA is closest to the small LOCA. The RCP seal LOCA was included because it may produce debris whereas safety or relief valves will not produce debris if they discharge to atmosphere or a quench tank.

10 There is a note indicating that the NUREG/CR-5750 large LOCA frequency has been updated to account for the V.C. Summer piping weld crack. What was the basis for assignment completely to the large LOCA category (as opposed to medium or small categories)?

RESPONSE:

The methodology used in NUREG/CR-5750, for estimating the frequency of large break LOCAs, is to estimate, for each throughwall crack in a large pipe, the conditional probability the crack will propagate to a LOCA. The estimated frequency of throughwall cracks in large piping, from data, was then multiplied by the mean conditional probability the crack will propagate to a LOCA. All LOCAs in large diameter piping were assumed to be large LOCAs. The updated frequency, taking into account the V.C. Summer event, was done in a manner entirely consistent with the original calculation. Since the Summer pipe crack was in a large pipe, only the large break data set is affected. The frequencies for SLOCA and MLOCA are determined from crack data for small and medium pipes, respectively. It should be noted that, if the size of the LLOCA were to be reduced, the effect would be to reduce the amount of generated debris. All the parametric cases were originally evaluated for a 95^{th} percentile LLOCA debris quantity, but have been re-evaluated assuming that the LLOCA debris quantity was the 50^{th} percentile value, which represent a significant decrease in debris. The use of the 50^{th} percentile resulted in a modest increase (i.e., 6) in cases being classified as Unlikely. Therefore, assuming a smaller LLOCA does not affect the conclusion that plant-specific analyses should be performed.

11 Consideration of seismically induced LOCAs is included in the assessment. However, as potential seismic impacts are highly site-specific, the consideration of such events would generally also require the consideration of plant location as a parameter, unless the objective is to perform a “bounding” assessment (i.e., not particularly realistic for any plant site). It was not clear, purely from slides how the seismic effects are being factored into the overall assessment and how these effects might influence the resulting cost-effectiveness decisions. Additional discussion of this topic is requested.

RESPONSE:

After the public meeting, the seismic contribution was recalculated with the revised LLNL hazard curves. The seismic contribution with the revised hazard curves was small, and therefore, it has been neglected. The proposed fix is cost-beneficial without including the seismic contribution; a more refined site-specific analysis will not change this conclusion.

12 The seismic initiating event frequency assigned to the Large LOCA category seems high. The category of events are those seismic events for which there is a high confidence that a consequential primary pipe break in the large size range would occur. As noted in question #10, this is a function of plant location, and the seismic fragilities of plant systems, structures, and components (SSCs). Aside from the fact that no detail is provided regarding how these issues are being accounted for, the magnitude of the frequency assigned for seismic Large LOCA seems inconsistent with the values assigned for medium and small LOCA categories. Additional discussion of this topic is requested.

RESPONSE:

After the public meeting, the seismic contribution was recalculated with the revised LLNL hazard curves. The seismic contribution with the revised hazard curves was small, and therefore, it has been neglected.

13 There is a note indicating that the “old (1988) LLNL hazard curves” from NUREG-1150 (Surry) are being used. What is the basis for selection of this particular hazard curve? Uncertainties in the debris accumulation study related to use of this particular seismic hazard curve should be addressed in the report.

RESPONSE:

After the public meeting, the seismic contribution was recalculated with the revised LLNL hazard curves. The seismic contribution with the revised hazard curves was small, and therefore, it has been neglected.

14a It is not clear how the “RECIRC” and “NON-RECOVERY” events are being used in the assessment relative to the probabilities being assigned. In many PWR PRAs, sequences requiring ECCS injection also require successful ECCS recirculation to result in a “success” end state (i.e., no core damage). Further, in these PRAs, any small LOCA sequence is generally modeled as requiring ECCS injection for success. Procedurally driven alternatives are usually not considered, since they would require significant plant and scenario-specific involving human actions with sufficiently significant failure probabilities such that default to the recirculation scenario is likely.

For the Small LOCA assumptions, it is not clear what the assigned “RECIRC” probabilities represent, or how they were assigned, particularly for the large dry containment case. Additional discussion of this topic is requested.

For both the Small LOCA and the RCP Seal LOCA cases, is “NON-RECOVERY” equivalent to failure of ECCS recirculation in the absence of consideration of debris-related sump blockage, or failure of ECCS recirculation including consideration of debris effects?

The values listed for “NON-RECOVERY” probabilities seem high if this event is intended to be ECCS recirculation failure (given successful ECCS injection) without consideration of debris-related blockage effects, especially for plants with automatic switchover to recirculation on low RWST (refueling water storage tank) level. Additional discussion of this topic is requested.

RESPONSE:

RECIRC means that ECCS recirculation is required to avoid core damage. In other words, cooldown and depressurization and use of the RHR in a hot shutdown mode of cooling is not successful. The procedures being used are those consistent with emergency response guidelines ES-1.2, “Post-LOCA Cooldown and Depressurization.”

The probability of "RECIRC" depends on several factors. To begin with, the cooldown and depressurization must be completed before the RWST is depleted. Secondly, in order to use the RHR, the break must be above the midplane of the hot leg. Otherwise it will not be possible to draw suction from the hot leg for the RHR system. (In the RHR mode of cooling, water is drawn from a hot leg and returned to a cold leg, after passing through the RHR heat exchangers. The water level in the hot leg must be above the midplane of the hot leg in order to have sufficient net positive suction head for the RHR pumps. If there is a break below the midplane of the hot leg, it is not possible to maintain the water above the midplane of the hot leg without replenishing the water in the reactor vessel; there would therefore be continued depletion of the water in the RWST, and it would not be possible to avoid going to sump recirculation for such breaks. On the other hand, if the break is above the midplane of the hot leg, then the leak will be terminated under RHR conditions, since the water in the RCS is subcooled, and minimal water vapor will leave through the break.) In a plant with a large dry containment, small break LOCAs above the midplane of the hot leg could be handled by cooldown and depressurization and use of the RHR, except for the possibility of operator error. In the analysis, a probability of 0.1 was assigned to RECIRC for a large dry. The operator actions are first to recognize that he must enter procedure ES-1.2 (for Westinghouse plants), nominally at 25 minutes into the accident. He must note that the RCS pressure at 25 minutes is so high that the LPI pumps are not injecting into the reactor vessel. He must then follow a specific procedure of stopping the HPI pumps and transferring the discharge of the charging pumps to the normal charging path, in order to depressurize and cooldown the primary side. The procedure is more complex than a normal cooldown without a LOCA, and must be completed before the RWST is depleted to the point where switchover to sump recirculation is required. In NUREG/CR-4550, vol. 5, rev. 1, part 2 (for Sequoyah), it is estimated, for a RCP seal LOCA, that the operator error is about 5%. The operator error may be larger for the larger size small break LOCAs (for example, a 2-inch LOCA) since there is less time available before RWST depletion. In addition, there may be actually be more than 5% of the small break LOCAs which are below the midplane of the hot legs, and consequently the estimate of 10% for RECIRC may be non-conservative. This would not affect the conclusions of the study.

NON-RECOVERY refers to the failure of the recovery actions referred to in ECA-1.1, “Loss of Containment Sump Recirculation.”

The change in the core damage frequency from fixing the sump screen clogging problem is given by the quantification of the following Boolean expression:

LOCA(n)*RECIRC*SUMP-CLOGS*NON-RECOVERY

If the sump clogging problem is fixed, it is assumed that this probability is zero. Note that the frequency associated with the above expression is zero if the probability of sump clogging is zero; the quantification of the above expression gives the change in core damage frequency from fixing the sump screen clogging problem. Failure of ECCS recirculation in the absence of consideration of debris-related sump blockage does not enter this expression.

14b For the case of RCP Seal LOCA, there is a high likelihood that the resulting leak will be sufficiently small that the event is effectively a Very Small LOCA (in which case the assumption on Slide #5 regarding no recirculation requirement applies). In this case, the assigned “RECIRC” probabilities make sense.

It is unclear why the plant response postulated for ice condenser plants following Small LOCA is different than that postulated for RCP Seal LOCA (i.e., “RECIRC” probability = 0.43 for RCP Seal LOCA but = 1.0 for Small LOCA). Given the overlapping ranges of possible break size equivalents for these two events, the application of different probabilities implies some unstated assumptions regarding distribution of events within these size ranges. Otherwise, it would seem that the same probabilities would apply. Additional discussion of this topic is requested.

RESPONSE:

The response of ice condenser plants is different for small LOCAs than for some RCP seal LOCAs because some RCP seal LOCAs are so small that the containment spray is not actuated, and it is possible to avoid ECCS recirculation by cooling down and depressurizing, then using the RHR in shutdown cooling mode. However, the containment spray will actuate on all small break LOCAs, in ice condenser plants, depleting the RWST before it is possible to get to RHR conditions. See p. D-70 of

NUREG/CR-4550, Vol. 5, Rev. 1, Part 2. Moreover, the setpoint for actuation of the containment spray is so low (2.8 psig at Sequoyah) that the operator cannot prevent depletion of the RWST by controlling the containment spray.

14c For the Sub-atmospheric containment Small LOCA case, it is not clear how the differentiation in assigned “RECIRC” probability (relative to the other cases) is justified. Failure of RHR, which is environmentally qualified, is not guaranteed given actuation of containment spray; further, failure of RHR does not guarantee failure of ECCS recirculation cooling, since plants with sub-atmospheric containments typically have a second system (e.g., recirculation spray cooling system) to provide recirculation cooling.

RESPONSE:

The RHR system is inside containment and is not environmentally qualified at Surry, according to the resident inspector there, or according to NUREG/CR-4550, Vol. 3, Rev. 1, Part 1, pp. 4.6-93. The RHR system is inside containment, not environmentally qualified, and not safety grade, at all plants with subatmospheric containments, except for Millstone 3. The fact that Millstone 3 was treated as the other subatmospheric plant does not affect the conclusions of the study.

Some credit was given for the RHR system in subatmospheric containments. Because the RHR system is not safety grade at Surry, it is not clear whether the operators will attempt to use it to mitigate a small break LOCA.

Failure of ECCS recirculation from causes other than sump screen clogging really does not enter into the expression for the change in core damage frequency from fixing the sump screen clogging problem. No assumption as to failing ECCS recirculation cooling by failing RHR was made.

15 How were values shown for the parametric evaluation of probability of sump clogging selected? The values shown imply that, unless there is no chance of clogging (i.e., P=0, the “unlikely” case), there is a significant chance of clogging (i.e., P=0.3, the “possible” case). The values selected do not appear to represent a reasonable probability distribution, unless the research results indicate an extreme sensitivity of clogging to the presence/generation of any debris at all. Changing the assigned probabilities by factors of ~2 is not likely to produce insights.

Unless there is always a significant chance of clogging the sump screen and the probability is not zero, then a more meaningful selection of values for this sensitivity might be P=1.0, P=0.1, P=0.01 or 0.001, and P=0.

RESPONSE:

The values for sump clogging probability are based on the qualitative designations for the results of each case in the GSI-191 parametric evaluation. The parametric evaluation used four qualitative designations to classify the results of the evaluation for each case and LOCA size: (1) Very Likely, (2) Likely, (3) Possible, and (4) Unlikely.

For cases where both the favorable and unfavorable conditions resulted in debris estimates greater than the minimum amount of debris needed to cause loss of NPSH, those cases and LOCA sizes were classified as Very Likely. Given the condition addressed in the parametric evaluation, cases with the Very Likely classification were assigned a probability of one, because both favorable and unfavorable conditions exceeded a minimum amount of debris, loss of NPSH could be considered a certainty.

For cases where both the favorable and unfavorable conditions resulted in debris estimates smaller than the minimum amount of debris needed to cause loss of NPSH, those cases and LOCA sizes were classified as Unlikely. Cases with the Unlikely classification were assigned a probability of zero, because neither favorable nor unfavorable conditions exceeded the minimum amount of debris. For a number of the Unlikely cases (esp. regarding LLOCA) the types of debris (e.g., metallic) used in the parametric cases are very difficult to transport and cause less head loss than other types of debris (e.g., calcium silicate).

For cases where the favorable condition resulted in debris estimates smaller than the minimum amount of debris needed to cause loss of NPSH and the unfavorable conditions resulted in debris estimates greater than the minimum amount of debris needed to cause loss of NPSH, those cases and LOCA sizes were classified as Possible or Likely. Since the results of the evaluation were not as conclusive as the other two classifications, a value between zero and one was assigned.

16 Slide 11 of the PRA presentation gave the impression that the assessment of Monetized Benefits from Averting Accidents Associated with Sump Clogging is being performed in a way that maximizes impact (and therefore maximizes benefits of aversion). This can be a valid approach, depending on the decision that the risk assessment is intended to support. That is, if the intent were to figure out what the worst possible effect could be in order to determine whether or not a more detailed estimate is needed, then a bounding approach is useful as a first (and potentially only) step. But if it is already known that a better estimate will be needed, then more realistic assumptions (and associated ranges or sensitivities to cover various cases) would be expected.

The information on Slide 11 suggests that the population dose analysis being applied is conservative in several ways. Stated conservatisms include application of effects of a scenario in which failure was during injection rather than recirculation and assignment of effects from Small LOCA to all events. Other conservatisms appear to be application of the Zion population density (even at the 80th percentile) as representative of all plants (many of which would have much lower population densities). Further, the statement that "The [results for the?] large dry containment type of plant may be optimistic for some plants …" seems to imply an inconsistent distinction of a particular plant characteristic that might result in less bounding results within this process, given the apparent application of layers of conservatisms elsewhere in the assessment.

The risk evaluation should use realistic assumptions, with sensitivities, rather than conservative assumptions when applied to the Monetized Benefits assessment.

RESPONSE:

The values used are given for the Zion plant in Table 5.3 of NUREG/BR-0184, "Regulatory Analysis Technical Evaluation Handbook," January 1997. The population density around Zion is not used; rather the population density at the 80th percentile of all sites is used (see NUREG/BR-0184, pp. B.17 and B.24). In other words, the results are as if the Zion plant had been moved to a place where the population density was equal to that of the 80th percentile nuclear power plant site in terms of the population density surrounding the site. The offsite consequence analysis for large dry and subatmospheric containment plants used Zion offsite consequences. Ice condenser plants used Sequoyah offsite consequences, and did not have the same conservatism as large dry containment plants. The change in core damage frequency associated with sump clogging may be underestimated for large dry containment plants which do not have emergency fan coolers and large RWSTs.

The conservatisms in the consequence analysis portion of the analysis are small, and do not affect the results. The greatest contribution to the benefits is the onsite property cost.

17 At the February 14, 2001 public meeting on GSI-191, industry identified a basis for using initiating event frequencies based on industry-sponsored Risk Based In-Service Inspection (RB-ISI) and break opening times from public literature. At that meeting, NRC was requested to identify how they would disposition that industry information. These event frequencies should be used in the risk assessments used in evaluating the significance of this issue.

RESPONSE:

The initiating frequencies from the RB-ISI program and other sources including NUREG/CR-5750 and NUREG/CR-1150 were considered. The values listed in NUREG/CR-5750 were considered the best available for the purposes of the GSI-191 averted CDF and benefit estimates. The staff acknowledges that there are uncertainties in the estimation of frequencies of LOCAs and other variables and evaluated their effects in the GSI-191 averted CDF and benefit estimates. The staff determined that the consideration of uncertainties does not affect the overall conclusion that plant-specific analyses should be performed.

18 At the February 14, 2001 public meeting on GSI-191, industry presented data that coatings failures reported by Savannah River [Technology] Center were beyond the conditions expected to occur in a PWR containment under normal and design basis accident conditions. The draft report specifically identifies the SRTC observations as a possible debris source. Based on this data the reference to the SRTC data should be removed from the report, since it is not applicable to plant operations.

RESPONSE:

The GSI-191 parametric evaluation does not explicitly use any particular type of particulate. It does list different types of particulate which include coating particulates. Whether coating particulates are included as a debris source should be determined on a plant specific basis. Therefore, references to the SRTC coating study will not be removed from the technical report.

Table 2: Responses to Comments Raised During Open Discussion of July 26 and 27, 2001 Public Meeting Concerning GSI-191

1 Expected NPSH margin not licensing NPSH margin should have been used in GSI-191 parametric evaluation.

RESPONSE:

At public meetings with the industry during the varous stages of the GSI-191 technical assessment, it was clearly stated that GL 97-04 would be used as the source for NPSH margin data. Expected NPSH margins were not made available for use by the NRC or NRC contractor.

2 The methodology used in the GSI-191 parametric evaluation does not provide any insight into when sump failure would occur.

RESPONSE:

Many of the time dependent parameters or plant conditions that affect timing vary widely from plant to plant. The GSI-191 parametric evaluation methodology was designed to minimize the need to rely upon time dependent parameters or plant conditions that affect timing. Because of the plant to plant variability with regard to number of time dependent parameters, this comment would be best addressed by plant-specific analyses.

3 The basis for assuming uniform accumulation of debris is unclear.

RESPONSE:

The parametric evaluation focused primarily on fine fibrous debris and particulate debris. Larger debris that may accumulate predominately at the bottom of the sump screen and debris that would accumulate at the top of the sump screen were not considered in the parametric evaluation. A number of debris accumulation tests were conducted with fine fibrous and particulate debris and demonstrated that the debris would be uniformly retained by mesh with 1/8 inch and 1/4 inch openings.

Separate technical reports are being prepared to describe the tests conducted to support the GSI-191 parametric evaluation. The technical reports that are being produced to document the work conducted to support the GSI-191 parametric evaluation should be released to the public by the end of February 2002.

4 The flowrate for non-Westinghouse PWRs used in the GSI-191 parametric evaluation appears to be too high.

RESPONSE:

This comment was raised with respect to a CE plant response to SLOCA events. The methodology for the parametric evaluation used 2500 gpm for ECCS recirculation flow following a SLOCA event. This information was based on a review of information contained in NUREG/CR-5640 for Westinghouse PWR high-pressure pump flow rates. The total ECCS flow available when the system has depressurized (to 500 psig) was assumed to be the nominal flow for use in the study. Review of the NUREG/CR-5640 information for Westinghouse PWRs concluded that this total available flow ranged from approx. 1900 gpm to 4800 gpm, with a median value of around 2500 gpm.

After the public meeting a review of SLOCA ECCS flow rates has been conducted for CE units. The information source for this review was the collection of nuclear plant information books on the U.S. NRC web site. Based on this review, it is concluded that the 2500 gpm value for ECCS recirculation flow is appropriate for use with CE units. For some units, the ECCS flow rate used in the parametric study may be half the value used. Plant variabilities such as this should be addressed in plant specific analyses.

It should be noted that the flow rate used to estimate the minimum amount of debris needed to cause loss of NPSH given a SLOCA, include the total ECCS and containment spray, not just ECCS flow rates.

5 The GSI-191 program did not include any head loss tests to benchmark the NUREG/CR head loss correlation against the type of debris assumed in the GSI-191 parametric evaluation.

RESPONSE:

The parametric evaluation only considered four types of debris that are common to most PWRs: (1) fiberglass, (2) metal, (3) calcium silicate, and (4) particulates. The fiberglass used in testing to develop and benchmark the NUREG/CR-6224 correlation has the same physical characteristics as the fiberglass commonly found in thermal insulation used in PWRs. The NUREG/CR-6224 correlation produces accurate estimates of head loss associated with fiberglass or combinations of fiberglass and particulates up to 50 ft of H_2O per inch of debris bed thickness. However, the NUREG/CR-6224 correlation has been shown to significantly under predict the head loss caused by calcium silicate debris. Use of the NUREG/CR-6224 correlation is appropriate without additional testing for a study intended to demonstrate whether debris accumulation is a problem for PWRs. Use of the correlation for plant specific analyses that involve debris types (e.g., calcium silicate) that were not part of the development of the correlation may be inappropriate.

6 Since the LLOCAs assumed in the GSI-191 parametric evaluation ranged from 6 inches

up, it seems inappropriate to use the 95-percentile debris generation value in the estimate of debris on sump screen.

RESPONSE:

The use of the 95^{th} percentile is appropriate for the parametric evaluation. The parametric evaluation does not include all possible debris sources and location of the debris sources is unknown. The use of the 95^{th} percentile for debris generation was chosen to partially offset these limitations in the parametric evaluation.

After the public meeting all the parametric cases were re-evaluated assuming that the LLOCA debris quantity was the 50^{th} percentile value, which represent a significant decrease in debris. The use of the 50^{th} percentile resulted in a modest increase (i.e., 6) in cases being classified as Unlikely.

The debris threshold is not dependent upon the debris generation or transport. For most cases the debris threshold was 2 ft^3 or less. So the use of a 95^{th} percentile had little impact on the finding of the study.

7 It was unclear from report and presentation if breaks were postulated in only high-energy lines inside the crane wall. It seems inappropriate to include non-high energy piping and piping outside of the crane wall in the parametric evaluation.

RESPONSE:

Breaks were postulated in high-energy (i.e., >500 psig) lines only. Breaks located outside the crane wall were included in the analysis. Because many plants have the ability to isolate breaks outside of the crane wall and thus prevent transition to recirculation, they could have been excluded from the parametric evaluation.

Because there is less piping in the zone of influence for breaks outside of the crane wall, inclusion of those breaks skews the distribution of possible debris volumes to lower values. If these breaks are removed from consideration, the 95^{th} percentile debris volume used to characterize small breaks may increase. So exclusion of breaks outside of the crane wall will not change the findings of the study.

8 The effectiveness of trash racks in reducing the amount of debris that could reach the sump screen was neglected.

RESPONSE:

The purpose of trash racks, which typically are built with floor gratings with 1 by 3 inch openings, is to stop large debris from reaching the sump screen. Large debris was not considered in the parametric evaluation. Only fine fibrous debris and particulate debris was considered in the parametric evaluation, typically trash racks would not accumulate fine fibrous debris and particulate debris. Analyses that consider all debris sources are better suited for assessing the effectiveness of trash racks.

9 It is unclear how distance debris travels in test facilities translates to distance debris travels in actual containment.

RESPONSE:

The distance in the tank tests do not scale to distances in actual containments. The tank tests do not represent a scale model of a containment floor. In order for credible scaled tests to be conducted that simulated conditions and configuration of an operating PWR, proportionate debris would have to be used. The results from the tank test were never intended to be applied to operating PWRs. The purpose of the tank tests was to demonstrate the feasibility of using data collected from the large flume tests and CFD prediction of flow patterns in containments to predict transport for a range of debris sizes (i.e., fines, shreds, and fluff) for inclusion in a detailed (i.e., similar to plant-specific) analysis. A detailed analysis was not conducted as part of the parametric evaluation.

Some of the tests conducted during the GSI-191 Technical Assessment were intended to support analyses that were not pursued because of changes in technical approach.

A separate technical report is being prepared to describe what tests were conducted to support the GSI-191 parametric evaluation. The technical reports that are being produced to document the work conducted to support the GSI-191 parametric evaluation should be released to the public by the end of February 2002.