July 16, 1992

Docket No. 52-001

Mr. Patrick W. Marriott, Manager
Licensing & Consulting Services
GE Nuclear Energy
175 Curtner Avenue
San Jose, California 95125

Dear Mr. Marriott:

SUBJECT: CONFIRMATORY AND OPEN ITEMS IDENTIFIED IN THE FINAL SAFETY EVALUATION REPORT (FSER) FOR CHAPTER 19, PROBABILISTIC RISK ASSESSMENT OF THE ADVANCED BOILING WATER REACTOR (ABWR)

The staff is developing the FSER for Chapter 19 of the GE Nuclear Energy (GE) ABWR Standard Analysis Report (SSAR). We have identified 20 preliminary confirmatory items where the staff and GE have reached tentative agreement. We also identified 49 preliminary open items where the staff and GE have not reached consensus. For each item, an amendment to the SSAR or revised inspections, tests, analyses and acceptance criteria, or additional information is required for complete closure.

Enclosed for your information is a summary of these confirmatory and open items.

Please contact me at (301) 504-1125 if you need additional information on these issues.

Sincerely,
Original Signed By:
Son Q. Ninh, Project Engineer
Standardization Project Directorate
Associate Directorate for Advanced Reactors
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Office of Nuclear Reactor Regulation

Enclosure:
As stated

cc w/enclosure:
See next page

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Docket No. 52-001

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LIST OF OPEN ITEMS

In the DSER (Outstanding Item 22, p. 19-187), the staff required GE to "provide information which describes (1) how PRA insights were used in the ABWR design process, (2) what ABWR design features, if any, were included as a result of PRA insights to reduce risk significant sequences and phenomena, (3) how plant operating experience was factored into the ABWR PRA, and (4) how PRA insights were used to address severe accident phenomena." In general, GE has not yet submitted final responses to these information requests. . . . .

GE did not submit, in time for this FSER, its reanalysis of the ABWR PRA based on the updated design. The staff has no up-to-date analysis of core damage frequency or containment failure for internal and external events. . .

The staff is awaiting the submittal by GE of an analysis of the important systems, structures, or components in the ABWR design with respect to the severe accident fire analysis. These components are to be factored into the reliability assurance program and the COL applicant's response to the maintenance rule. This analysis is expected during June 1992. . . . .

The staff is awaiting GE's final submittal of its internal flooding analysis. To date, GE has provided partial drafts of its analysis, all of which were deterministic. The staff expects GE to submit its internal flooding analysis in June 1992 including insights to be included in the reliability assurance program and the COL applicant's response to the maintenance rule. . . . .

The staff is awaiting GE's submittal of its external flooding analysis.

On May 7, 1992 and June 9, 1992, GE provided draft portions of the information requested by the staff on risk in modes other than full power. The staff expects the complete submittal, including an evaluation of the reliability of the decay heat removal system, to arrive in June 1992. . . . . .

The list provided by GE of design features that are expected to significantly improve core damage frequency and risk estimates is incomplete. For example, it does not address the increase in the drywell head design pressure, the physical separation of safety divisions in the design, and improvements in the design to withstand external events and LOCAs. . . . . .

GE has committed to provide a comparison between the dominant sequences from applicable existing BWR PRAs and those of the ABWR PRA. This comparison has not been supplied to the staff in time for inclusion in this FSER, but is expected in July 1992. . . . . .

GE did not provide a list of systems, structures, and components for both internal and external events that should be used by the COL applicant to help develop its reliability assurance program. GE did not address reliability targets for such equipment nor did GE provide the results of its importance analyses evaluations. The staff expects this information to be submitted in June 1992. . . . . .

GE did not provide DAC and ITAAC based on evaluation of the ABWR PRA for both internal and external events. The staff expects this information to be submitted in June 1992. . . . . .

As part of the staff's review of the ABWR PRA, the staff intends to evaluate effectiveness of the ABWR PRA in identifying vulnerabilities and leading contributors to risk for the ABWR. To support the staff's assessment, GE has committed to provide a discussion of vulnerabilities discovered during the performance of the ABWR PRA (May 28, 1992 fax from GE). This information is expected to be submitted in June 1992. The staff will utilize this additional information in evaluating GE's use of PRA in the ABWR design process, and will include the results of this evaluation in a supplement to the FSER. . .

By fax dated May 28, 1992, GE has committed to provide a discussion of the balance between prevention and mitigation for the ABWR. The staff expects this to be submitted in late June 1992. The staff will utilize this information as well as the results of the updated PRA (also to be submitted in late June) to develop PRA perspectives on the balance between prevention and mitigation. These perspectives are expected to be incorporated as part of the severe accident closure chapter of the SER (Chapter 22). . . . . .

The staff has performed a preliminary evaluation of design alternatives for severe accident prevention and mitigation, as required by 10CFR34.f. The results of this evaluation indicate that none of the design alternatives analyzed by GE are justified on the basis of cost benefit considerations. However, this analysis will be further evaluated by staff, to take into consideration: (1) the effect of revised PRA results, including corrections to the consequence calculations discussed in Section 19.9, (2) the effect of different cost benefit criteria, and (3) the value of additional design alternatives not treated by GE. . . . . .

GE agreed to provide an analysis of the contribution of support system failures as initiating events in the ABWR PRA. This analysis was not provided by GE in time to be included in this FSER. The staff expects the final analysis of the contribution of support system failures to be submitted to the staff by GE in June 1992. . . . . .

In the DSER (O-3, p. 19-185), the staff noted that GE did not provide results of accident analyses of postulated interfacing LOCA events as applicable to the ABWR design. Subsequently, GE has agreed (as documented in a fax from GE dated May 28, 1992) to upgrade and document the quality of its piping that interfaces between high and low pressure systems. The staff has continuing questions about whether the proposed interfacing piping upgrades are adequate to remedy staff concerns regarding interfacing LOCAs. . . . . .

After discussion with GE it was determined that GE had performed an evaluation of LOCAs outside of containment, but that there were errors in the analysis. The staff has not yet received an updated version of this analysis for internal and external events. The staff expects GE to submit this information in June 1992. . . . . .

The staff required in the DSER that GE provide a systematic analysis of risk for the ABWR design during modes other than full power. The staff refined its

request during meetings with GE (December 9th and 10th, 1991, San Jose, California). GE has provided draft portions of the requested analysis to the staff in a meeting in San Jose on May 8, 1992. The staff expects GE to submit the balance of the requested analysis, including an analysis of decay heat removal reliability, during June 1992. . . . . .

In the DSER the staff required GE to provide further justification that its train-level common mode failure analysis was able to capture the full contribution to common mode failure probability had it been calculated at the component level. In further discussions with GE, the staff refined its request to require GE to requantify the PRA with and without taking into account the additional areas of common mode failure that were not in the ABWR PRA as originally submitted by GE. The results of this sensitivity study will be used to provide insights into what additional systems, structures, or equipment should be added to the reliability assurance program or GE's response to the Maintenance Rule. GE has indicated it intends to provide this information in June 1992. . . . . .

In the DSER the staff required GE to provide a list of systems not included in the GE nuclear island, the assumed reliability for each system, and any safety significant insights GE believes are important to designing the systems to meet the assumptions of the PRA. In a fax dated May 28, 1992, GE indicated that it will supply this list in June 1992. . . . . .

After completion of the DSER, the NRC's Advisory Committee on Reactor Safeguards (ACRS) performed an independent investigation of the Reactor Water Cleanup (RWCU) System. They found that the success criteria were suspect and found that the system would isolate on high temperature, rather than act as a high pressure, high temperature heat removal path. GE agreed and by Fax dated May 28, 1992 indicated that GE would modify the ABWR design to make the RWCU system work as was assumed in the ABWR PRA. The staff is awaiting the final submittal from GE addressing the modified design and the justification that the RWCU heat exchangers would not experience too large a temperature differential during high temperature, high pressure transients. The staff expects GE's submittal in June 1992 including RWCU and condensate and feedwater system fault trees. . . . . .

By fax dated May 28,1 1992, GE agreed to supply a sensitivity analysis of equipment outage times in its PRA requantification. . . . . .

In the DSER the staff identified GE's modeling and analyses of human errors in the ABWR PRA to be lacking in details and documentation that is essential for scrutability of the results and derivation of insights. Technical concerns raised by the staff in the DSER Outstanding Items O-7, O-8, and O-9 (p. 19-186 of the DSER) are closely related. No documentation has been provided by GE to resolve these issues. The staff expects GE to respond in June 1992.

In the DSER (O-10, p. 19-186), the staff requested GE to perform of sensitivity and uncertainty analyses of human errors modeled in the ABWR PRA. The staff has not received complete analysis in this area. . . . . .

In the DSER the staff identified Confirmatory Item C-5 (p. 19-181) and six Interface Items (I-2 to I-7, p. 19-188 to 19-189) in the area of Human

Reliability Analyses. Resolution of these issues hinges on design details that are not currently available (e.g., control room design, plant-specific data, man/machine interface for advanced technologies). The staff and GE have agreed on a resolution path for these items, but the staff is awaiting the PRA input to DAC/ITAAC and guidance to the COL applicant. . . . . .

In the DSER the staff required GE to provide an input to the reliability assurrance program that lists the equipment to be included into the program and provides reliability targets for systems and/or components. By fax dated May 28, 1992, GE has indicated it intends to supply this information in June 1992. . . . . .

After the DSER, the staff informed GE that it would need to investigate the ABWR PRA to determine what inputs were sufficiently important to be included and at the same time actually capable of being included (i.e., measured) in ITAAC. . . . . .

In the DSER the staff stated that GE had to perform an uncertainty analysis for internally initiated events. In a fax dated May 28, 1992, GE agreed to supply the analysis including an analysis of initiating event uncertainty. The staff expects it to be submitted in June 1992. . . . . .

Because the original seismic analysis was based on an outdated plant design, GE is submitting a new seismic analysis. By fax dated May 28, 1992, GE indicated that this new submittal, expected in June 1992, will concentrate on providing high confidence, low probability of failure (HCLPF) values for core damage sequences and for the plant. This analysis will consist of a PRA-based seismic margins analysis. The analysis is to identify seismic capacities for systems not in the Certified Design. . . . . .

In the DSER the staff stated that it wanted the COL applicant to confirm the seismic capacities of structures, systems, and components modeled in the PRA and wanted these capacities to be included in the design specifications for the equipment. In a fax dated May 28, 1992, GE stated that this would probably be covered by the PRA input to the ITAAC program. Such a solution would be acceptable to the staff, but the applicable ITAAC was not provided in time for evaluation in this FSER. . . . . .

In the DSER the staff pointed out that the ABWR PRA did not address the failure of containment penetrations and isolation valves during a seismic event. GE has submitted several drafts to the staff discussing this area. The staff is awaiting a final submittal from GE. By teleconference GE indicated the final submittal will be supplied in June 1992. . . . . .

In discussions with GE regarding its analysis of seismically-induced LOCAs that bypass containment, GE indicated that the safety relief valve discharge lines appear to have HCLPFs in the range of 0.6g for the portion of the piping in the wetwell air space. The staff is awaiting GE's discussion of the methodical search it performed for such potential failures. . . . . .

Because the original ABWR PRA submittal, including the seismic analysis, was based on an outdated plant model, GE is submitting a remodeled, requantified PRA. The staff expects that there will be some modifications to the seismic

fault trees, even though they are simplified from that for internal events. The staff's evaluation of the seismic fault trees in GE's original ABWR submittal is documented in the DSER. No conclusions about the robustness of the design with regards to beyond design basis seismic events can be made without an updated set of seismic fault trees. The staf expects GE to submit these fault trees in June 1992. . . . . .

GE has made draft statements that would appear to allow some penetrations between divisions to be qualified to a lower standard if the penetrations contain non-safety equipment. The staff has sought clarification of this statement since these penetrations could conceivably become pathways for a fire to spread between divisions. . . . . .

The staff is still evaluating the spread of smoke in safety-related buildings other than the reactor building. . . . . .

Because only assumptions and no design details were available for certain parts of the design that are to be the responsibility of the COL applicant (e.g., the ultimate heat sink), there needs to be a fire ITAAC that covers those parts of the design that are not within GE's nuclear island. . . .

The staff is awaiting the submittal by GE of an analysis of the important systems, structures, or components in the ABWR design with respect to the severe accident fire analysis. These components are to be factored into the reliability assurance program and the COL applicant's response to the maintenance rule. This analysis is expected during June 1992. . . . . .

Subsequent to the DSER, the Commission required that severe accident internal flooding be analyzed at the Design Certification stage (Internal flooding was originally assigned in the DSER as Interface Item number 9). GE and the staff have had extensive discussions on this analysis. The staff expects GE to submit its internal flooding analysis in June 1992. . . . . .

Interface Item number 8, page 19-189 in the DSER required the COL applicant to "(p)erform a site-specific design verification for truly 'external' events, such as external floods and transportation hazards, for which no analyses can be performed at this stage." The ABWR SSAR concludes that it would be acceptable to build an ABWR at a site as long as it was as little as one foot above the probable maximum flood (PMF) level. Because of the potential seriousness of severe accident external floods, the staff considers this issue to be an Open Item. . . . . .

Submittal of GE's complete and final containment bypass analysis is expected in late June. . . . . .

By telefax dated May 28, 1992, GE committed to provide documentation indicating results of sensitivity and uncertainty analyses in regard to the COPS, and giving the basis for the COPS setpoint. The staff's expectation is that these analyses will be based on GE's modified CETs, which were presented in a preliminary form during a June 12 and 15, 1992 technical meeting with staff. This submittal is expected in June 1992. . . . . .

The staff also noted in the DSER, that venting in less than 24 hours should not be equated with containment failure (DSER page 19-157), and committed to separate these issues in the FSER. This was identified as Staff Correction 9. The staff will address this matter as part of the review to be reported in the FSER supplement. . . . . .

By telefax dated May 28, 1992, GE committed to provide documentation indicating results of sensitivity and uncertainty analyses in regard to the passive flooder system. It is the staff's expectation that these analyses will be based on GE's modified CETs, preliminary versions of which were presented by GE during a technical meeting on June 12 and 15, 1992. Submittal of the analyses is expected in late June. . . . . .

The staff will review the information to be provided by GE regarding the modified CET and DETs, and supporting MAAP and structural calculations regarding core concrete interaction. . . . . .

A remaining issue related to FCI is energetic FCIs, or steam explosions. Such interactions occur on the order of milliseconds in contrast to rapid steam generation events, which occur on the order of seconds. GE contends that an ex-vessel FCI due to a rapid energy transfer from the debris entering water in the lower drywell is precluded by pressure/temperature regimes and the debris particle size (SSAR Section 19E.2.3.1). The staff considers this justification to be inadequate, and will require GE to provide additional rationale for excluding this phenomena from consideration in the PRA. This should include an assessment of the applicability of experimental data on FCI to the ABWR design, and scoping analyses of the ability of the ABWR to sustain a FCI for both the situation in which water is added to a pre-existing debris bed in the lower drywell cavity, and the situation in which core debris is added to a pre-existing water pool in the lower drywell. . . . . .

The objectives of the Level 2 uncertainty treatment are to acknowledge and represent within the context of the containment analysis, the full range of outcomes for those issues that are highly uncertain. This is in contrast to a more simplified approach where uncertainty issues (perhaps bimodal in nature) are represented in the CET by a single, "best-estimate" outcome.

It is the staff's view that the present approach being pursued by GE (i.e., use of decomposition event trees for selected key issues) is consistent with these objectives and is therefore acceptable. However, to date GE has only submitted partial, preliminary analyses. Submittal of complete analyses are expected in late June 1992. . . . . .

The staff will complete its review of the source term uncertainty analysis for the ABWR after submittal of the GE analysis. . . . . .

By fax dated May 28, 1992, GE committed to provide the results of the updated ABWR PRA (Levels 1, 2, and 3). The updated PRA results will reflect modifications to the plant design incorporated subsequent to the DSER, as well as modelling enhancements and corrections identified by GE and staff since the original PRA. This information is expected to be submitted in late June 1992. Based on this revised information, the staff will provide an update assessment of the integrated risk results for the ABWR. . . . . .

In response to ACRS and staff concerns, GE has revised their suppression pool bypass analysis, and provided additional clarification regarding the effects of a break in the RWCU suction line. This information was provided to the staff in a draft form. Based on the revised analysis, GE has identified two additional bypass lines that will now be treated as potential bypass paths in the containment event tree (in addition to the wetwell-drywell vacuum breakers, which were previously identified for inclusion in the event trees). These are the drywell purge exhaust and the inerting lines. The containment event trees for these bypass paths are still to be provided by GE. Additional discussion on containment event trees for containment bypass is provided in Section 19.7.2 of the FSER.

With regard to breaks in the RWCU suction line, GE has indicated that the system arrangement and emergency procedure guidelines provide assurance that unisolated breaks will not result in core uncovery and long term releases. Specifically, the physical layout of piping routes the RWCU lines above the core to avoid a potential siphon of the core inventory. In addition, should the isolation valves fail to close, the EPGs would require lowering the RPV level to below the reactor vessel's shutdown cooling suction penetration, and depressurizing the RPV. GE contends that these actions should be possible prior to any impact of breakflow on other ECCS equipment.

The staff has not completed its review of the information provided by GE, and is awaiting GE's complete submittal on this issue. As part of this review the staff will address whether the information provided by GE is sufficient to continue to exclude treatment of ex-containment LOCAs from the PRA. The results of the staff review will be provided in a supplement to the FSER.

The ACRS is correct that GE erroneously took credit for the RWCU system at high pressure during transients and GE has moved to correct this design deficiency. It is the staff's understanding that GE has redesigned the isolation logic of the RWCU system, realigned the isolation configuration so that only the heat-vulnerable resin beds are isolated on high temperature, and limited the total isolation of the RWCU to those periods when the containment isolation function is actuated. In addition, since the RWCU would only be put into operation by emergency procedure after the RHR had failed, cooling water would be diverted by procedure from the RHR heat exchangers to the RWCU heat exchanger to limit the temperature increase across the RWCU heat exchanger. GE calculates that this temperature increase is only a few degrees above the design temperature and argues that this is acceptable, since the RWCU is a back up system that would only have to be used in this configuration for very low probability, beyond design basis events. The staff is awaiting GE's complete submittal (expected in June 1992) addressing the RWCU concern. .

LIST OF CONFIRMATORY ITEMS

Since most of the interaction between the staff and GE has been in the form of faxes and information exchanged (and documented) at meetings, any conclusion regarding severe accident fires in this FSER are Confirmatory Items pending inclusion of the relevant information in the ABWR SSAR, including appropriate COL Applicant Items.

The staff is awaiting a significant number of submittals from GE and has not received them in time for consideration in this FSER. For example, the staff has not yet completed its review of the following: the overpressure protection system, the core flooder system, GE's external event analyses, and GE's requantification of the PRA. Therefore, the conclusion that the ABWR design, at a high level, represents a significant improvement in reduction of estimated core damage frequency from internal events is a Confirmatory Item.

In a fax dated May 28, 1992, GE committed to use a 0.1 IORV event per year frequency in its updated PRA. The staff finds this acceptable, but considers the item to be a Confirmatory Item until the updated PRA is submitted by GE (expected in June 1992) and reviewed by the staff.

In the DSER the staff questioned ambiguities in the write up on the Inadvertent Opening of the Safety Relief Valve (IORV) event. In a fax dated April 14, 1992, GE provided a draft mark up of its SSAR and indicated it will amend the PRA text to clarify the text and the accompanying Table.

In the DSER the staff said GE should have taken credit for the use of the fire water system in both level 1 and level 2 parts of the ABWR PRA as was done by the staff, rather than just the level 2 portion. GE noted in a fax dated May 28, 1992 that the GE position was conservative from a core damage frequency standpoint. However, the staff insisted that it was important to model those systems that could prevent or mitigate important events so that their value could be evaluated for inclusion in the reliability assurance program. In its fax of May 28, 1992, GE indicated that the fire water system is to be included in the reliability assurance program.

In a fax dated May 28, 1992, GE indicated that it will increase the assumed test and maintenance unavailabilities and include these new values in its updated PRA. The staff finds this to be acceptable. The staff expects GE to submit the updated PRA to the staff in June 1992.

Upon further evaluation by GE, GE has indicated by teleconference with the staff that it does not intend to perform a sensitivity study of its surveillance intervals, since GE is very standard about these times and has not intention of changing them.

The staff's evaluation of GE's quantification approach used in combination with its design-specific and generic data to quantify the sequence frequency estimates is provided in the DSER. As indicated therein, a number of minor errors in GE's analysis were identified, but were corrected in the staff's requantification. The staff will review the revised PRA submitted by GE to

confirm that these errors have been corrected in GE's final risk analysis.

As is done in most PRAs, GE has grouped postulated accident sequences into a small set of accident classes. The staff's review of the accident classes used by GE is reported in the DSER. The staff found that the accident class definitions used by GE are acceptable, but noted some potential inconsistencies with regard to the classes to which certain sequences were assigned in the PRA. The staff will confirm the adequacy of GE's accident sequence classification as part of the review of the updated PRA, and will report the results of this review in a supplement to the FSER.

In the DSER the staff indicated that it believed the fuel assembly seismic capacity was optimistic. After numerous discussion and submittals to the staff, the staff agrees that a capacity of 1.2g is achievable and is a reasonable value.

In the DSER the staff indicated that it believed that the capacities of flat-bottomed tanks, diesel generators, and electrical equipment were optimistic and would need to be evaluated at time of plant construction. In a fax dated May 28, 1992, GE indicated that it is considering reducing these capacity assumptions. Reduction of these capacities is agreeable with the staff.

In the DSER (I-12, p. 19-189), the staff stated that COL applicants must perform a plant walkdown to examine the as-built ABWR for potential seismic-related problems. By fax dated May 28, 1992, GE agreed to have COL applicants perform a plant walkdown according to the procedures in EPRI NP-6041. Use of the EPRI guidance is acceptable to the staff.

In the DSER (the DSER called this Staff Correction number 3, p. 19-182), the staff pointed out that the ABWR PRA incorrectly took too much credit for firewater as a mitigating system in the Seismic Class II CET. By fax on May 28 1992, GE stated that it will correct this CET.

The evaluation of the seismic event trees for the ABWR PRA is documented in the DSER. It is possible that with the PRA update, one or two event trees may be modified. If new trees are submitted by GE, the staff will reevaluate the applicable tree(s).

By fax dated May 28, 1992, GE committed to correct the treatment of firewater in the seismic containment event tree (Noted in the DSER as Staff Correction number 3, p. 19-182) and to include the correction in the PRA-based seismic margins analysis to be submitted to the staff in June 1992. As part of the review of this submittal the staff will confirm that the above concerns have been addressed and will report the results of this review in a supplement to the FSER.

The staff will confirm the adequacy of GE's accident sequence classification as part of the review of the updated PRA, and will report the results of this review in a supplement to the FSER.

With respect to an uncertainty analysis of fragilities, the use in the PRA-based margins method of a high confidence, low probability of failure (HCLPF)

value to help judge the robustness of the plant implicitly takes into account of the variability of the fragilities. The HCLPF is the acceleration at which there is a 95% confidence that less than 5% of the time the equipment will fail. The staff expects GE to submit the HCLPF values for the updated ABWR design in June 1992

An additional review item related to this issue concerns the composition of concrete used in the lower drywell. The staff indicated in the DSER that GE intends to use basaltic concrete, and that this type of concrete is preferable to limestone concrete due to lower rates of erosion and non-condensible gas production from CCI. The results of more recent calculations by GE, presented during a June 12 and 15, 1992 meeting with staff, provide further support for the use of basaltic concrete. These calculations explored core debris coolability and concrete erosion under various assumptions, and suggest that COPS actuation would occur at about 17 to 20 hours after scram in the presence of extensive CCI. COPS actuation would occur even earlier if limestone concrete were used. Accordingly, the staff will require that as part of Design Certification for the ABWR, a Tier 1 requirement be established to specify that basaltic concrete shall be used in the construction of the ABWR lower drywell floor and reactor pedestal. The staff will review this design commitment, and report the results in a supplement to the FSER.

By submittal dated April 2, 1992 GE provided their analysis of pool swell and flashing. Based on a preliminary review by the staff, the GE analysis appears reasonable. However, the staff has requested its contractor to review the details of the analysis, and this portion of the review has not yet been completed.

Subsequent to issuance of the DSER, however, GE identified an error in the way that weather data was read into the CRAC2 code used for the consequence calculations. As a result of this error, wind speeds were systematically overestimated, and offsite consequences underestimated in the ABWR results reported in the DSER.

By fax dated May 28, 1992, GE committed to correct this error in the revised consequence calculations that will accompany the updated PRA. These calculations are expected to be submitted in late June 1992.