Entergy®

**Entergy Operations, Inc.**
17265 River Road
Killona, LA 70057-3093
Tel 504-739-6660
Fax 504-739-6698
djacob2@entergy.com

**Donna Jacobs**
Vice President - Operations
Waterford 3

W3F1-2012-0083

October 16, 2012

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

SUBJECT: 90-Day Response to Request for Additional Information Regarding Adoption of National Fire Protection Association Standard NFPA 805
Waterford Steam Electric Station, Unit 3
Docket No. 50-382
License No. NPF-38

REFERENCES:

1. Entergy letter W3F1-2011-0074 "License Amendment Request to Adopt NFPA 805 Performance-Based Standard for Fire Protection for Light Water Reactor Generating Plants (2001 Edition)", Waterford Steam Electric Station, Unit 3 dated November 17, 2011
2. Entergy letter W3F1-2012-0005 "Supplemental Information in Support of the NRC Acceptance Review of Waterford 3 License Amendment Request to Adopt NFPA 805 Waterford Steam Electric Station, Unit 3" dated January 26, 2012
3. NRC Transmittal to Entergy dated July 18, 2012, "Request for Additional Information Regarding Adoption of National Fire Protection Association Standard NFPA 805 (TAC No. ME7602)"

Dear Sir or Madam:

In letter dated November 17, 2011, as supplemented by letter dated January 26, 2012 (References 1 and 2), Entergy Operations, Inc. (Entergy) submitted a License Amendment Request (LAR) for Waterford Steam Electric Station, Unit 3 (Waterford 3) to adopt a new, risk informed - performance based, fire protection licensing basis under 10CFR50.48(c).

In letter dated July 18, 2012 (Reference 3), the NRC staff made a Request for Additional Information (RAI) needed to complete its review which included a set of questions due in 60 calendar days and a set of questions due in 90 calendar days. Attachment 1 provides the responses to those questions considered as the NRC's 90 calendar day RAI's, based on communications on August 23 and September 25, 2012, requesting various extensions of 60 day responses to 90 days.

There are no new regulatory commitments contained in this submittal.

If you require additional information, please contact the acting Licensing Manager, Michael E. Mason, at 504.739.6673.

I declare under penalty of perjury that the foregoing is true and correct. Executed on October 16, 2012.

Sincerely,

DJ/AJH

Attachments:

1. Additional Information (90 day responses) in Support of NRC Review for Waterford 3 NFPA 805 License Amendment Application

cc: Mr. Elmo E. Collins, Jr. RidsRgn4MailCenter@nrc.gov
Regional Administrator
U. S. Nuclear Regulatory Commission
Region IV
1600 E. Lamar Blvd.
Arlington, TX 76011-4511

NRC Senior Resident Inspector Marlone.Davis@nrc.gov
Waterford Steam Electric Station Unit 3 Dean.Overland@nrc.gov
P.O. Box 822
Killona, LA 70066-0751

U. S. Nuclear Regulatory Commission Kaly.Kalyanam@nrc.gov
Attn: Mr. N. Kalyanam
Mail Stop O-07D1
Washington, DC 20555-0001

Louisiana Department of Environmental Quality Ji.Wiley@LA.gov
Office of Environmental Compliance
Surveillance Division
P.O. Box 4312
Baton Rouge, LA 70821-4312

**Attachment 1 to**

**W3F1-2012-0083**

**Additional Information (90 day responses) in Support of NRC Acceptance Review for Waterford 3 NFPA 805 License Amendment Application**

**Additional Information (90 day responses) in Support of NRC Acceptance Review for Waterford 3 NFPA 805 License Amendment Application**

Additional information was requested by the NRC Staff on July 18, 2012 in support of the Review for Waterford Steam Electric Station, Unit 3 (Waterford 3) License Amendment Request (LAR) dated November 17, 2011. The following provides the Entergy additional information requested by the NRC staff (90 day responses).

## PROBABILISTIC RISK ASSESSMENT (PRA)

### RAI PRA 01

*Please describe how the evaluation includes the possible increase in heat release rate (HRR) caused by the spread of a fire from the ignition source to other combustibles and summarize how suppression is included in the evaluation*.

### Waterford 3 Response

No secondary ignition concerns (except for cables/targets in direct contact with the ignition source) were identified in the baseline Waterford 3 fire PRA. In response to the RAI, walkdowns of Waterford 3 physical analysis units (PAUs) were performed and locations of plausible secondary ignition targets were recorded. Using insights from this activity and based on PAU specific assessments, secondary ignition targets were identified in only two PAUs which resulted in additional dependent faults due to the expansion of the fire zone of influence provided by the secondary ignition. These PAUs were RAB 8A and RAB 27 and are discussed in RAI PRA 40.

Suppression was not included in the baseline analysis. Suppression will be considered in the refinement associated with these PAUs consistent with the guidance in NUREG/CR-6850.

### RAI PRA 02

*Transient fires should at a minimum be placed in locations within the plant physical analysis units (PAUs) where conditional core damage probabilities (CCDPs) are highest for that PAU, (i.e., at pinch points). Pinch points include locations of redundant trains or the vicinity of other potentially risk-relevant equipment, including the cabling associated with each. Transient fires should be placed at all appropriate locations in a PAU where they can threaten pinch points. Hot work should be assumed to occur in locations where hot work is a possibility, even if improbable (but not impossible), keeping in mind the same philosophy. Please describe how transient and hot-work fires are distributed within the PAUs. In particular, please identify the criteria which determine where an ignition source is placed within the PAUs. Also, if there are areas within a PAU where no transient or hot-work fires are located since those areas are considered inaccessible, please describe the criteria used to define "inaccessible." Note that an inaccessible area is not the same as a location where fire is simply unlikely, even if highly improbable.*

Waterford 3 Response

**Transients (other than Hot Work)**

The baseline transient fire evaluations (used to support LAR submittal) are documented in reports PRA-W3-05-006 and PRA-W3-05-001. An updated analysis was performed for transient fire scenarios for each of the 31 risk significant PAUs. The selected PAUs are the 31 PAUs addressed by the Waterford internal fire PRA Fire Risk Evaluations (FREs). These transient fire analyses assume that transient fires are possible at any location within the individual PAUs and they do not discredit any unoccupied location within any of these selected PAUs. Occupied space is defined as floor area that is physically occupied by equipment or previously analyzed storage cabinets (e.g. - "electrical safety equipment storage" located in the switchgear rooms). Occupied floor area transient fire ignition frequency was not lost; but rather the ignition frequency became denser in the unoccupied areas of the specific PAU, maintaining the same overall PAU transient fire ignition frequency. In addition, the transient fire analyses used the 98$^{th}$ percentile heat release rate for transient ignition sources contained in NUREG/CR-6850 to determine fire scenario impacts.

Sub-PAUs were utilized to analyze the PAU on a more refined basis. The use of sub-PAUs combined with allowing a transient fire to occur anywhere within the individual sub-PAUs ensures that all pinch points are identified. Sub PAUs were formed based on the impact of pinch points within the PAU.

The transient fire scenarios also looked at "likelihood of storage". To understand where transients might be stored a thorough plant-specific walkdown was conducted and a review of the combustible control procedure (EN-DC-161 R6) was completed. This portion of the analysis allows for frequency to be increased in those areas deemed to be a "high likelihood of storage" area. Since the transient fire ignition frequency is fixed, ignition frequency was reduced equally from all floor area that was considered a "low likelihood of storage". No frequency was lost and no area was assigned a zero frequency during this process.

Hot work was addressed using two methods, the first includes the transient fires caused by hot work frequency (those transient fires not involving cable ignition) with the rest of the transient fires frequencies (scenario impacts as discussed above), and the second method evaluates cable fires caused by hot work separately. See the Hot Work section of this response for more details.

There is one fire area that is considered inaccessible. It is the ‘radioactive pipe chase’ RAB 23A. It is a sealed compartment that has several cable trays/conduits running through it. It is sealed by concrete block walls. Access to this area requires the floor plugs or part of the wall to be removed.

Response to RAI PRA 40 describes the impact of these transient fire scenarios in regards to CDF and LERF.

**Transients Due to Hot Work**

The baseline transient fire evaluations (used to support LAR submittal) are documented in reports PRA-W3-05-006 and PRA-W3-05-001. An updated analysis was performed for transient fire scenarios for cable tray fires caused by hot work and re-quantified the CDF and LERF using whole PAU impacts (whole room burns) for each of 31 selected PAUs. By analyzing these scenarios at a whole PAU level, hot work is assumed to be possible at any location within the various PAUs and is not discredited in any location within any of these selected PAUs. The selected PAUs are the same 31 PAUs contained in the above transient evaluations.

The ignition frequency for fires due to transient hot work activity such as welding and cutting (listed as bin 5, 11, or 31 of NUREG/CR-6850, depending on plant location of the particular

PAU) was taken from the Waterford Plant Partitioning and Fire Ignition Frequency Development report (PRA-W3-05-001) as documented in the referenced engineering calculation file, below. To facilitate the assignment of influence factors and to better isolate the impact of hot work from general maintenance activities, the maintenance weighting factor has been subdivided into two components: mechanical/electrical maintenance and hot-work. The weighting factors developed in the Waterford Plant Partitioning and Fire Ignition Frequency Development Notebook were developed using the methodologies contained in NUREG/CR-6850 and are appropriate for this updated analysis, and are further investigated in response to RAI PRA 03, which states:

> "In developing transient fire frequencies, weighting factors for several variables were determined. The weighting factors for occupancy, storage, and maintenance (divided into hot work and mechanical/electrical type activities) were developed. Application of the weighting was in line with the guidance provided in NUREG-6850. A rating of "0" was used for only one PAU. Zero was listed for maintenance, occupancy and storage for the Radioactive Pipe Chase. This area is physically inaccessible. Access to the area requires knocking a hole in a concrete block wall. All other influence factors applied were 1, 3, 10, or 50. While the rating of "3" was not the most common value applied ("1" was the most common), the average factor for all inputs was approximately 2.6 (Table 3-13 of WSES3 Fire PRA Plant Partitioning and Fire Ignition Frequency Development report)."

As many of the PAU hot work cable tray transient fires were screened in the baseline internal fire PRA, representing a zero contribution to the overall CDF and LERF, a direct percentage increase for each PAUs CDF and LERF contributions due to these fire scenarios is not possible. Most of the selected PAUs in this study present an insignificant contribution to CDF and LERF when quantified as whole PAU impact scenarios. The dominating PAU scenarios still present only small contributions to CDF and LERF. The overall contribution to CDF and LERF is given for each of the 31 selected PAUs in the analysis (reference 1 below). When summed, the contribution to CDF and LERF for transient cable tray fires due to hot work for all of the 31 selected PAUs represents less than 15% of the overall CDF and LERF. The quantitative impacts are presented in RAI PRA 40.

**References**

1. Report RSC 12-22, Transient Fire Summary Report, Revision 0, RSC Engineers, Inc.

RAI PRA 03

*Please discuss the calculation of the frequencies of transient and hot-work fires. Please characterize the use of the influence factors for maintenance, occupancy, and storage, noting if the rating "3" is the most common, as it is intended to be representative of the "typical" weight for each influence factor. It is expected that the influence factor for each location bin associated with transient or hot-work fires will utilize a range of influence factors about the rating "3," including the maximum 10 (or 50 for maintenance) and, if appropriate, even the rating "0." Note that no PAU may have a combined weight of zero unless it is physically inaccessible, administrative controls notwithstanding. In assigning influence factor ratings, those factors for the Control/Auxiliary/Reactor Building are distinct from the Turbine Building; thus, the influence factor ratings for each location bin are to be viewed according to the bin itself.*

*If any influence factors outside of the values identified in Table 6-3 of NUREG/CR-6850, "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities," September 2005*[1]*, have*

*been used, please identify the values used, identify the PAUs that use these factors, and justify the assigned factor(s).*

Waterford 3 Response

The Fire PRA did not use factors outside of those provided in NUREG-6850. The influence factors applied to the Waterford physical analysis units (PAUs) are documented in the WSES3 Fire PRA Plant Partitioning and Fire Ignition Frequency Development report. The factors are listed in Table 3-13 of the report. No exceptions to the NUREG-6850 were applied.

In developing transient fire frequencies, weighting factors for several variables were determined. The weighting factors for occupancy, storage, and maintenance (divided into hot work and mechanical/electrical type activities) were developed. Application of the weighting was in line with the guidance provided in NUREG-6850. A rating of “0” was used for only one PAU. Zero was listed for maintenance, occupancy and storage for the Radioactive Pipe Chase. This area is physically inaccessible. Access to the area requires knocking a hole in a concrete block wall. All other influence factors applied were 1, 3, 10, or 50. While the rating of “3” was not the most common value applied (“1” was the most common), the average factor for all inputs was approximately 2.6 (Table 3-13 of WSES3 Fire PRA Plant Partitioning and Fire Ignition Frequency Development report).

The numerical rankings developed for Waterford were summed for each PAU and then normalized across all PAUs included in the generic plant locations that are the basis of the fire ignition frequencies provided by NUREG/CR-6850. These generic locations for transient fire ignition frequency allocation are:

- Containment (PWRs)
- Control / Auxiliary / Reactor Building (CAR)
- Turbine Building (TB)
- Plant Wide (PW)

Each activity influence rating was assigned for each category for each PAU. The influence values provide a means to establish a relative, progressive ranking of the physical analysis units that is used to distribute the averaged aggregated fire frequencies to each PAU. NUREG/CR-6850, Table 6-3, provides a framework for this assignment and includes suggested influence factor values. This guidance was used to develop the ranking criteria for this analysis. Table 3-13 of PRA-W3-05-001, Revision 0 identifies the influence factor rankings, definitions and values that are used for development of the PAU influence factors as adapted from NUREG/CR-6850.

RAI PRA 06

*Section 10 of NUREG/CR-6850 states that a sensitivity analysis should be performed when using the fire ignition frequencies in the Supplement instead of the fire ignition frequencies provided in Table 6-1 of NUREG/CR-6850. Please provide the sensitivity analysis of the impact on using the Supplement 1 frequencies instead of the Table 6-1 frequencies on core damage frequency (CDF), large early release frequency (LERF), delta (Δ) CDF, and ΔLERF for all of those bins that are characterized by an alpha that is less than or equal to one. If the sensitivity analysis indicates that the change in risk acceptance guidelines would be exceeded using the values in Table 6-1, provide justification for not meeting the guidelines.*

<u>Waterford 3 Response</u>

After applying the fire ignition frequencies from Table 6-1 of NUREG/CR-6850, the resultant CDF and LERF contributions increase by almost a factor of 2. The total CDF contribution for fire increased from 3.40E-5 to 5.93E-5 (ΔCDF = 2.53E-5), while the total LERF contribution for fire increased from 7.34E-7 to 1.26E-6 (ΔLERF = 5.26E-7). Details of the sensitivity analysis are shown in calculation file RSC-CALKNX-2012-0826.

According to NRC Regulatory Guide 1.174 (Section 2.2.4), when a calculated increase in CDF is in the range of $10^{-6}$/reactor year to $10^{-5}$/reactor year, the increase is considered acceptable only if it can be reasonably shown that the total CDF is less than $10^{-4}$/reactor year (Region II). When a calculated increase in LERF is in the range of $10^{-7}$/reactor year to $10^{-6}$/reactor year, the increase is considered acceptable only if it can be reasonably shown that the total LERF is less than $10^{-5}$/reactor year (Region II). Based on the results of the sensitivity analysis, the total CDF and LERF contributions and the ΔCDF and ΔLERF satisfy these requirements. The cumulative impacts of this sensitivity study are in the response to RAI PRA 40.

<u>RAI PRA 08</u>

*Attachment W of the LAR provides the ΔCDF and ΔLERF for the variances from the deterministic requirements (VFDRs) for each of the fire areas, but the LAR does not describe either generically or specifically how ΔCDF and ΔLERF were calculated. Please describe the method(s) used to determine the changes in risk reported in the Tables in Attachment W. The description should include:*

a. *A summary of Probabilistic Risk Assessment (PRA) model additions or modifications needed to determine the reported changes in risk. If any of these model additions used data or methods not included in the FPRA Peer Review, describe the additions.*

b. *Identification of new operator actions (not including post MCR abandonment which are addressed elsewhere) that have been credited in the change in risk estimates. If such actions are credited, describe how instrument failure is addressed in the human reliability analysis (HRA).*

<u>Waterford 3 Response</u>

a. The FRE assessments to support the VFDRs utilized the application FRANC. The quantification was based on a revision of the PAU condition to that of compliant conditions and determining the associated changes in CDF and LERF. The method of quantification was the "True" method; see RAI PRA 58 (60 Day RAI Submittal) response for details regarding this method. No changes in modeling or methods were made to the peer reviewed version of the Fire PRA while being used in the FRE task. The process is documented, supporting this conclusion in each FRE calculation.

b. No new operator actions were included within the scope of the FREs used to support the VFDRs. The process is documented in the FRE calculation file for each of the PAUs assessed.

RAI PRA 15

*Since cable damage thresholds and horizontal flame spread rates along cables are based on the type of cable (thermoplastic versus thermoset), please describe why a zone of influence (ZOI) is based on Institute of Electrical and Electronics Engineers (IEEE)-383 qualification rather than the type of cable employed as a decision step. An IEEE-383 qualified thermoplastic cable is still subject to the lower damage threshold (-205 degrees Celsius (°C)) and higher horizontal flame spread rate (-0.9 millimeters/second (mm/sec)) of thermoplastic cables. It further appears that IEEE-383 qualification rather than type of cable is being used to determine hot gas layer (HGL)-ZOI. A temperature of 329°C is cited as the damage threshold for IEEE-383 qualified cables, which would be appropriate only if they are thermoset, regardless of IEEE-383 qualification. (See PRA-W3-05-005, "Waterford FPRA Multi-Compartment Analysis and HGL ZOI Evaluation," pages 2-5 and 2-6, Figures 2-2, 69 kilowatt (kW) heat release (HR) Screening, and 2-3,702 kW HRR Screening; page 2-7, §2.6, Conclusions; page 3-2, §3.1, Purpose; pages 3-4 and 3-5, Figures 3-2, 69 kW HR Screening, and 3-3, 702 kW HRR Screening; PRA-W3-05-006, pages 2-8 and 2-9, §2.2, Assumption 8; pages 4-1 and 4-2, §4.0, Damage Criteria.) Please provide reanalysis that applies the correct assumptions.*

*Also, in PRA-W3-05-006, page 10-1, §10.2, Cable Tray Propagation, the statement that thermoset materials do not propagate flames is incorrect. There is a horizontal spread rate of -0.3 mm/sec, and vertical spread is also likely, as per NUREG/CR-6850, including frequently asked question (FAQ) 08-0049 in Supplement 1, and the recent results from CHRISTIFIRE tests, NUREG/CR-7010, "Cable Heat Release, Ignition, and Spread in Tray Installations During Fire (CHRISTIFIRE)" [draft for comment (ADAMS Accession No. ML 102700336), dated October 31, 2000; NPA version (ADAMS Accession No. ML 120540103) dated May 31, 2012).] Assuming no vertical propagation because Waterford has thermoset cables would be incorrect. Please provide reanalysis that applies the correct assumptions.*

Waterford 3 Response

The design specifications for Waterford 3 cables required IEEE-383 qualification. The materials of construction of the cables are consistent with thermoset performance which was the basis for the determination for the FPRA. Findings from supplemental plant walkdowns following the audit documented in RSC 12-18 support this conclusion based on a sampling of raceway cabling. The walkdown did confirm the existence of a very limited number of cables of a thermoplastic nature installed by a design change. These cables are associated with low voltage signals for multiplexer units and are located in non-safety related raceways in several physical analysis units (PAUs).

The majority of these cables are located in PAUs where fires are conservatively assumed to result in a complete loss of the PAU and the cable damage threshold is not a critical parameter due to the assumed damage. These PAUs are the turbine building, cable spreading room and RAB 27, for which the assessment will be refined. The evaluation will treat the identified cables in a manner consistent with the guidance in NUREG/CR-6850 assuming a thermoplastic material property. In the remaining PAUs, the cable population in any specific raceway is between 1 and 5 cables which is estimated to have a small impact on any existing analyses. In many cases, the thermoplastic cables are shielded by thermoset cables within the tray which would preclude significant heating to the point of damage.

With respect to vertical burning, the walkdown found that the thermoplastic cables were located primarily in horizontal runs and/or were contained in raceways that were covered. Thus, the potential impact from vertical burning would be limited.

RAI PRA 16

*In PRA-W3-05-006, pages 4-3 and 4-4, §4.2, Sensitive Electronics, the screening-level failure thresholds for sensitive electronics, 3 kiloWatts per square meter (kW/m$^2$) and 65°C, are at least twice as low as those for thermoplastic cables, let alone thermoset (330°C and 11 kW/m$^2$) which is the assumed base cable type. NUREG/CR-6850 allows a "relaxation" of the temperature threshold to 82°C if the sensitive electronics have been "qualified" at that temperature. Please provide a fire phenomenological/heat transfer calculation to confirm that "[e]:xtrapolating this argument to cabinets which are not 'adjacent,' it can easily be seen that separation distances beyond the ZOI associated with cable damage [presumably thermoset, which is less conservative than thermoplastic] are more than sufficient to preclude damage to sensitive electronics housed in cabinets." Also, please provide the basis for assuming that all sensitive electronics are contained within "sealed" cabinets, and therefore presumably immune to smoke damage when the smoke originates from outside the cabinet. (See PRA-W3-05-006, page 4-5, §4-3, Smoke Damage*.)

Waterford 3 Response

Damages to sensitive electronics beyond the ZOI of an electrical cabinet fire were screened at Waterford 3 with the following basis. The primary factor in screening is associated with the bin 15 scenario selection methods. While some bin 15 scenarios have only a single electrical cabinet as the ignitions source, most scenarios included multiple cabinets. The multiple source scenarios have higher frequencies and account for damage to all included sources. In many cases, 15 to 20 cabinets (or Electrical Equivalence Units - EEUs) are included in individual scenarios. The criteria for the selection and grouping of the bin 15 fires was cabinet location. Attached, adjacent, and nearby (not directly adjacent, but close by) electrical cabinets were grouped into individual scenarios. Solid state component damage due to heat up of cabinets not included in the scenario were not explicitly evaluated, primarily because the cabinets most subject to such damage were already included in the scenarios (Examples – RAB 7A has a bin 15 count of 33 but only has 6 bin 15 fire scenarios. RAB 8B has a bin 15 count of 144 split among only 24 fire scenarios).

The second criterion for screening damage to non-adjacent sensitive electronics was the air gaps and enclosures between the source and the potential damage. NUREG/CR-6850 Attachment S provides some guidance to include adjacent cabinets (S.2 'Damage to Adjacent Cabinets'). This suggests that damage to sensitive electronics in directly adjacent cabinets would be significantly delayed. The protection afforded by the panel enclosure (no non-enclosed solid state electrical components were identified during walkdowns) and the larger air gap associated with the target panel being 'non-adjacent' are significant. With the guidance in Attachment S and the additional protection the horizontal distance and enclosure provide, damage to sensitive electronics in 'non-adjacent', sealed electrical panels was determined to be insignificant (failure of the components determined unlikely). Any potential damage that could propagate to a non-adjacent panel would also be mitigated by room cooling (if functional) and any active fire suppression (which is more likely given the time required to reach damage in non-adjacent equipment).

The above justification for treatment of sensitive electronics has some limitations. Upon reevaluation, the approach is only valid for well-sealed electrical cabinets (Waterford 3 has both sealed and vented panels). Nor does it consider transients and other fixed ignition sources (non-bin 15 sources). Damage to sensitive electronics can occur from any fire and consideration is not limited to only bin 15 fires. The following sections list changes to this approach that have been made or are in progress.

The transient calculations completed to support responses to PRA RAIs 01, 02 and 18 included an expanded ZOI for solid state electronics.

Work to analyze the impact of such fires is currently in progress. The impact from transient fires has been evaluated. No impact is assumed to occur in non-adjacent panels from fires in well-sealed electrical cabinets. Current efforts are ongoing to check and update scenarios associated with vented panels and other fixed ignition sources. Preliminary findings show the impact to be insignificant (in several PAUs, no new targets were found with the expanded ZOIs). However, Waterford 3 will update all scenarios to ensure the impact to sensitive electronics is adequately captured and analyzed. This ongoing effort to update fixed ignition source scenarios to expand ZOIs for sensitive electronics will satisfy the concerns about sensitive electronic treatment (from fixed ignition sources only) in PRA RAIs 17, 20, and 23.

Regarding smoke damage:

The assumption regarding well sealed cabinets was the result of walkdown observations. Cabinets containing sensitive electronics (e.g., solid state control cabinets as those typically found in the MCR or Aux. Panel Room) are not always distinguished from cabinets which contain no sensitive electronic equipment. FAQ 08-0042 was used as guidance in determining which panels were closed and well sealed. Not all components identified as bin 15 ignitions sources (electrical cabinets) are well sealed. Most are, but many are not. For example: RAB 7A and 7B (relay rooms) have 52 electrical cabinets – all were judged to be well sealed in fire scenario development. RAB 8A (switchgear room) has 27 bin 15 sources, 12 are enclosed panels with vents and have fires with ZOI determination, 15 were judged to be well sealed.

The conclusion from the guidance (Attachment T of NUREG/CR-6850) states:

> The current state of knowledge cannot support detailed quantitative assessments of smoke damage as a part of a Fire PRA. As described above, information relating to smoke damage thresholds remains lacking, and the current fire modeling tools as applied in Fire PRA do not provide the necessary analytical capabilities.

In accordance with the discussion in Appendix T of NUREG/CR-6850, of the failure modes attributable to smoke damage, only circuit bridging was found to be of potential risk significance. Smoke related circuit bridging requires a very high concentration of smoke. No "exposed" sensitive electronics were identified during the scenario walkdowns. Sensitive electronics are all contained in sealed or otherwise closed (robustly secured panels with vents). These enclosures, even ones with vents, would limit high concentrations of smoke.

A fire within an enclosure was assumed to cause a loss of function of all equipment in the enclosures and therefore the effects of any smoke generated internally were bounded. High voltage power components at WSES are also contained within enclosures that would limit smoke density exposure. Smoke removal capability within some areas of concern (switchgear rooms and MCR) serve to further reduce the potential impact on enclosed components from external smoke effects.

Since the guidance states that quantitative assessment of smoke damage is not feasible, qualitative judgment based on W3 design determined the effects of smoke to be limited and essentially bounded by the already modeled scenarios (Ref. PRA-W3-05-006). As with the non-adjacent sensitive electronics, the components most likely susceptible to smoke related damage are already included in the individual scenario groupings. Additionally, the vast majority of sensitive electronic components are in well sealed cabinets which are not impacted by smoke exposure.

<u>RAI PRA 18</u>

*In the Transition Report, page V-14, Attachment V, Table V-1, Fire PRA Peer Review F&Os, the disposition for F&O PP-A 1-01 states that "Transient sources would not include sufficient loading to challenge the 2-hour rating." Please describe whether this considers the possibility of transient HRRs more severe than those assumed in the Unreviewed Analysis Method that used the 69 kW HRR for many transient combustible fires. Please describe whether the Sensitivity Analysis of the method addressed this possibility. Specifically, in PRA-W3-05-009, "Waterford FPRA Sensitivity Evaluation to Address Alternate Methodologies Report," at least some of the combustible control limits for the Levels 1 and 2 transient fires seem more than sufficient to produce a higher HRR than 69 kW, possibly as high as the 317 kW, 98th percentile value recommended in NUREG/CR-6850. Please describe whether at least one of the following transient combustibles administratively controlled in Level 2 Areas could produce a higher HRR than 69 kW:*

a. *100 pounds (lbs) of fire retardant lumber (contribution to fire limited based on fire retardant characteristics),*
b. *25 lbs of loose ordinary combustible or plastics,*
c. *5 gallons (gal) of combustible liquids in approved containers (contribution to fire will be limited based on use of approved container),*
d. *1 pint of flammable liquid in approved containers (contribution to fire will be limited based on use of approved container), or*
e. *one 20-ounce (oz) flammable aerosol can (material within can would require fire due to fixed ignition source or other transient to become flammable, typical ignition source associated with overloaded temporary cable or sparks/slag from welding are unlikely to involve flammable material within an aerosol can).*

*Please describe the basis for a priori dismissal of all the above combustibles.*

*Further, in the Transition Report, on pages V-17 and V-18, §V.2.1, Reduced Heat Release Rate for Transient Combustible Fires; unless there is a physical constraint on the amount of combustibles (i.e., not just "administrative controls"), the Sensitivity Analysis should consider the possibility of higher HRRs, such as 317 kW, in Levels 1 and 2 areas. Not only total CDF and LERF, but also ΔCDF and ΔLERF need to be addressed, both plant-wide (cumulative) and per PAU (or other unique subdivision). On pages V-18 and V-19, §V.2.2, Adjustment Factor for the Transient Combustible Fire Ignition Frequency. the citing of FAQ 08-0044, related to mechanical feedwater pump (MFWP) oil fires, should be FAQ 08-0048.*

*Related to these, PRA-W3-05-009, "Waterford FPRA Sensitivity Evaluation to Address Alternate Methodologies Report," contains extensive discussion of the use of a 98th percentile HRR of 69 kW for screening and modeling of transient combustible fires in selected locations, specifically the following: (Note that in Appendix E, multi-compartment analysis (MCA) Initial Screening, of PRA-W3-05-005, "Waterford FPRA Multi-Compartment Analysis and HGL ZOI Evaluation Report," numerous fire zones listing "transient" as an ignition source type use the 69 kW value as the HRR for screening evaluation.)*

i. *On pages 2-7,15 of the 21 tests used in NUREG/CR-6850 to generate the transient combustible fire HRR curve are dismissed as inapplicable or inappropriate. Fire testing in a relatively small enclosure (at least compared to nuclear power plant (NPP) rooms) is common practice to measure HRR (oxygen consumption calorimetry). Dismissal of these room tests leaves only six on which to base the HRR profile. For a fire up to -300 kW, the room will have no significant effect on fire behavior. A HGL is needed to approach the flashover conditions where the feedback effect begins to have an impact. Further, tests should not be discarded because the fires occurred against a wall or*

*corner. The effect of the wall or corner on the actual burn behavior is relatively small and more complicated than "intensifying the fire." Proximity to walls may actually limit fire intensity during some stages by restricting the free-flow of fresh air (hence oxygen) to the fire, and a cold wall can absorb a lot of heat during the first few minutes. Any feedback is not a factor for some time. The use of an "accelerant" to ignite a test fire does not justify dismissing the test outright, as the HRR contribution from the accelerant would be minimal once the fire develops. The basis for discarding fire tests due to "plastic pool fires" is also questionable since several of the tests included a plastic bucket or trash can that melted down into a pool. Also, dismissal of the test fires ignited with a liquid, generally in small quantities that burn off quickly, ignores that use of a liquid as igniter is common for fire testing.*

ii. *On pages 10-11, a review of the impact on CCDP based on fixed ignition sources in several of the Level 3 and 4 locations is used at least as partial justification for not postulating any "worse" potential CCDP locations ("pinch points") for transient combustible fires. Describe if the targets potentially impacted only by the fixed ignition sources, bound the highest CCDP possible in the area, (Le., describe if it is possible for a transient combustible fire to be particularly located where it could damage a pinch point with a CCDP higher than any for the fixed ignition sources) Also, even if a transient fire could be located where it impacts a target already modeled for impact by a fixed ignition source, describe if the additional fire frequency from the transient fire impacting that target would merit inclusion in the risk estimate. If it was previously screened out due to the lower assumed HRR, its contribution would not be included in the existing estimate with the fixed ignition source, so it would have to be added as part of the Sensitivity Evaluation. In addition, the statement regarding the turbine generator building (TGB) that "increasing the size of this fire will not alter the CCDP or CDF for this scenario" may only be partially true. While the CCDP would not increase, being already set at the maximum for the base scenario, the CDF could increase if there is additional contribution via the frequency due to potential damage from a transient fire with a greater HRR, if that fire was previously dismissed when screened out due to lower HRR.*

iii. *It is stated on pages 19-20 that "Routing of the cables of concern away from these scenarios is at an elevation of greater than 12.4', ensuring that a 317 kW fire will not be able to damage the cables." Describe the ZOI for the 317 kW fire. Describe if there any other cables or combustibles within the ZOI that could be ignited and, through fire propagation, damage the cables of concern if not suppressed. In addition, when estimating the reduced CCDP =3.96E-4 for fires in the "other" locations, describe whether all five listed components are excluded simultaneously (Electrical Switchgear (ESWGR)-31A and RC-MPMP-0001A through 2B)? Some of the nine scenarios affect as few as only two of these five components, such that at least three others could be affected and should be included in the CCDP. If the CCDP = 3.96E-4 represents exclusion of all five, it is only appropriate if all five components are affected by a scenario. Those scenarios affecting less than all five would be expected to have a CCDP between 3.96E-4 and the maximum of 0.106. Also, the assumption of an automatic reduction in CCDP by a factor of 2 appears arbitrary, especially in light of the potential underestimate of CCDP for some of the "other" scenarios.*

iv. *On pages 28-34, §2.S.2, Transient Combustible HRR and Transient Adjustment, citing the zones in RABXX as immune to the use of the 317 kW HRR analysis is questionable given the previous comments on pages 2-7.*

Waterford 3 Response

The baseline analysis used the 69 kW HRR for transient combustible fires and did not consider the possibility of a more severe HRR. The "Sensitivity Evaluation to Address Alternate Methodologies" report (PRA-W3-05-009) did consider the possibility of barrier failure; it concluded that there was no impact to the MCA when a more severe HRR (317kW) was used.

A review of the administrative control limits identified that the 69kW HRR is not bounding. The re-evaluation considered the aforementioned combustible listing when re-evaluating the transient fire scenarios completed with RAI PRA 02 response which did use 317 kW, the 98th percentile HRR value recommended in NUREG/CR-6850, for transient fires. This 317 kW HRR was also used for any transient combustible scenario within the administratively controlled Level 2 areas and it is expected that the 317 kW transient fire, HRR would encompasses transient combustible loadings within these areas. Furthermore, the basis used for excluding the higher overall HRRs than 69 kW in the baseline Waterford 3 fire PRA model was not used during the completion of the new transient fire scenario re-evaluations. It would be expected for overall HRRs above 69 kW to be present for items such as the list of combustible/flammable materials in the above RAI text, and that the use of the NUREG/CR-6850 overall transient fire source HRR of 317 kW better encompasses potential transient combustible materials. The new analysis is based on the guidance in NUREG/CR-6850 and does not include any reduction factors.

See RAI PRA 16 response for fixed ignition sources.

Response to RAI PRA 40 describes the quantitative impact of the updated transient fire scenarios described above.

RAI PRA 20

*Please describe the basis for the selection of 69 kW and 702 kW as the HRR groups for the HGL screening and whether the HRR increased for the potential contribution due to fire spread to other combustibles, such as propagation horizontally or vertically along cables. Also, since sensitive electronics are assumed to be potentially damaged at 82°C (See Appendix S of NUREG/CR-6850), please describe whether attainment of the 80°C threshold was considered for failure for sensitive electronics (vs. the next screening level of 220°C). (See PRA-W3-05-003, pages 2-1 and 2-2, §2-2, Methodology, and §2.3, Background/Analysis Inputs.)*

Waterford 3 Response

The selection of the 69 kW HRR is based on application of an Unreviewed Analysis Methodology (UAM) directing that the expected HRR for a transient fire can be approximated by the 98$^{th}$ percentile HRR for electric motor fire scenario from NUREG/CR-6850 with the justification that the majority of transient fires are electrical in nature. The impact of the UAM on transient fire scenarios overall is addressed in the response to PRA RAIs 02 and 18. The quantitative impacts are presented in RAI PRA 40 response. The sensitive electronics failure criterion is also further investigated in response to RAI PRA 16.

The selection of the 702 kW HRR is realistic for items such as switchgear or MCC cabinets, and is seen as an appropriate HRR to use as an upper bound to potential cabinet scenario HRRs when evaluating the potential for hot gas layer formation. The 702 kW HRR is based on the “vertical cabinets with qualified cable, fire in more than one cable bundle” category from

NUREG/CR-6850 from the 98th percentile HRRs for various ignition sources. The PRA-related cables at the Waterford plant are qualified IEEE-383 type and constructed of thermoset materials as found in safety-related trays. Using the multiple bundle HRR is conservative compared to using the single qualified cable bundle cabinet fire scenario HRR of 211 kW, also from NUREG/CR-6850.

For potential increased overall HRR due to fire spread or propagation, the hot gas layer analysis for the 702 kW ignition source calculates the 80 °C and 220 °C probability of a hot gas layer as an initial screening check using 1750 kW which accounts for the original 702 kW electrical cabinet ignition source and secondary ignition(s) leading to the overall scenario HRR of 1750 kW. See Figure 2-3 of the Waterford Multi-Compartment Analysis and Hot Gas Layer Evaluation Notebook (PRA-W3-05-005) for a flowchart of this activity.

In addition, further investigation of secondary ignitions was undertaken as part of the response to RAI PRA 01 and the impacts are presented in RAI PRA 40 response.

The 80 °C criterion is not applied for cabinets with sensitive electronics as stated in Section 4.2 of the Waterford Fire Scenarios Report (PRA-W3-05-006).

This approach is outside of the NUREG/CR-6850 methodologies. As discussed in the response to PRA RAIs 17 and 23, studies performed in response to the Waterford internal fire PRA RAIs use the NUREG/CR-6850 recommended failure criteria for sensitive electronics that may be contained within cabinets of a temperature level of 65 °C or a heat flux level of 3 $kW/m^2$. The use of 65 °C as a criterion for the hot gas layer evaluation could result in fewer ignition sources being screened from consideration as the 65 °C temperature level could be surpassed while the currently evaluated 80°C temperature level is not surpassed which would allow screening. It is also expected that the use of these lower failure criteria will produce more limiting scenario results (that is, that there will be an increased occurrence of predicted cabinet failures within various PAUs for fire scenarios within the PAU) than the results presented in current Waterford internal fire PRA, which could in turn impact the overall results of the fire PRA.

The application of the NUREG/CR-6850 recommended sensitive electronics failure criteria can be found in the sensitivity studies performed in response to RAI PRA 02. This assessment indicated that the more restrictive criterion for failure was not a significant limitation for transient fire sources and did not significantly alter the potential impacts from the assessed transient fire sources.

<u>RAI PRA 25</u>

*In the Transition Report, page V-19, §V.2.3, Adjustment Factor for the Hot-work fire Ignition Frequency, credit for administrative controls during hot work is embedded in the NUREG/CR-6850 hot-work fire frequencies. This Unreviewed Analysis Method was not accepted by the consensus industry-NRC panel and was replaced with an alternative approach. As such, it should not be retained in the FPRA. "A sensitivity analysis was performed by increasing the hot work frequency reduction factor for 'cable fires caused by welding and cutting' and 'transient fires caused by welding and cutting' from 0.01 to 1.0. The results of this evaluation show that the CDF increased from 3.42E-5/yr to 4.24E-5/yr. This represents an overall CDF increase of approximately 24 percent. This evaluation shows the results are still within the guidelines for transition found in NRC Regulatory Guide (RG) 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," Revision 2, May 2011 (ADAMS Accession No. MI100910006), and RG 1.205, "Risk-Informed, Performance-Based Fire Protection for Existing Light-Water Nuclear Power Plants," Revision 1, December 2009 (ADAMS Accession No. MI092730314). Provided this was done for all hot work*

*PAUs, this sensitivity is acceptable. However, LERF, ΔCDF, and ΔLERF sensitivity results should also be provided. Related concerns are as follows:*

a. *In W3F1-2012-0005, page 3 of 7, SO 3, Alternate Method #3, Adjustment Factor for Hot Work Ignition Frequency, assuming this refers to Item S1-5 in the LAR, please describe to what proposed procedural modifications this reference applies. S1-5 cites a proposed installation of 3M electrical raceway fire barrier system (ERFBS) in reactor auxiliary building (RAB) 5 and 6 only. Also, please describe whether the reference to Item S2-8 is for procedure EN-DC-127 and whether hot work will now be prohibited versus limited/controlled, in RAB 5 and If not, then please describe whether the 0.01 reduction factor is still being applied and if yes, please provide the Sensitivity Results for these locales without this credit.*

b. *b. In PRA-W3-05-006, page 8-2, §8.1, Suppression and Detection Random Failure Probabilities; page 8-3, §8.2, Hot-work fire Scenarios, a failure probability of suppression during hot work procedures of 0.01 is cited, which is apparently based on the original Unreviewed Analysis Method. Please provide the methods Sensitivity Analysis that uses the modified, accepted version of this method, as per the consensus industry-NRC panel.*

c. *In PRA-W3-05-009, pages 24-26, §2.4, Adjustment Factor for the Hot Work Ignition Frequency, the hot work correction factor of 0.01 was applied only to scenarios in RAB 5 and RAB 6, as listed in Table 2.4.1, and the increases in ignition frequency and CDF are slightly less than a factor of 10 when the correction factor is increased to 1 (a 100-fold increase). Please describe whether it is correct to assume that the transient fire frequencies listed in Table 2.4.1 include contributions from non-hot work transient fires, thereby accounting for the overall increase by "only" 24 percent.*

Waterford 3 Response

An analysis was performed that removed the UAM factor of 0.01 from transient fire scenarios for cable tray fires caused by hot work and re-quantified the CDF and LERF using whole PAU impacts (whole room burns) for each of 31 selected PAUs. The selected PAUs for the analysis are the 31 PAUs addressed by the Waterford internal fire PRA Fire Risk Evaluations (FREs).

The ignition frequency for fires due to transient hot work activity such as welding and cutting (listed as bin 5, 11, or 31 of NUREG/CR-6850, depending on plant location of the particular PAU) was taken from the Waterford Plant Partitioning and Fire Ignition Frequency Development Notebook (PRA-W3-05-001) as documented in this analysis. To facilitate the assignment of influence factors and to better isolate the impact of hot work from general maintenance activities, the maintenance weighting factor has been subdivided into two components: mechanical/electrical maintenance and hot-work. The weighting factors developed in the Waterford Plant Partitioning and Fire Ignition Frequency Development Notebook were developed using the methodologies contained in NUREG/CR-6850 and are appropriate for this study.

In this analysis, no credit was taken for proposed procedure modifications, proposed barrier system, or hot work preclusion at Waterford 3. This includes PAUs RAB 5 and 6, as well as the remaining selected PAUs analyzed as part of this study.

Also, in this analysis, non-suppression probabilities for automatic suppression systems and manual fire suppression were credited as appropriate. A non-suppression probability of 0.05 was used based on NUREG/CR-6850 methodology and information contained in Appendix P of NUREG/CR-6850. For the PAUs with no installed automatic suppression system or PAUs with an installed automatic suppression system that is not credited, no credit is taken for installed

sprinkler non-suppression probability. A uniform non-suppression probability is applied to all PAUs for manual fire fighting response. A time of 15 minutes is used for the manual response non-suppression probability based on listed time to damage for secondary cable targets of 19 minutes from NUREG/CR-6850 or a time to damage of 15 minutes as determined in the sensitivity study for sensitive electronics. At 15 minutes, the non-suppression probability for welding fires is 0.06, as taken from Appendix P of NUREG/CR-6850.

The contribution from non-hot work transient fires was not included in Table 2.4.1. Most of the selected PAUs in this study present an insignificant contribution to CDF and LERF when quantified as whole PAU impact scenarios. The dominating PAU scenarios still present only small contributions to CDF and LERF. The overall contribution to CDF and LERF is given for each of the 31 selected PAUs in the analysis. When summed, the contribution to CDF and LERF for transient cable tray fires due to hot work for all of the 31 selected PAUs represents only a minor percentage of the overall CDF and LERF. The quantitative impacts are presented in the RAI PRA 40 response.

RAI PRA 26

*In the Transition Report, pages V-19 and V-20, §V.2.4, Adjustment Factor for Electrical Cabinet Ignition Frequency, although apparently limited in use only to screening, this Unreviewed Analysis Method is not accepted by the NRC. The screening should be re-performed with no credit for this factor, or using fire modeling phenomenology that is generically bounding. Also, in W3F1-2012-0005, page 3 of 7, SO 3, Alternate Method #4, Adjustment Factor for Electrical Cabinet Ignition Frequency, it is stated that "... [T]his method has only negligible impact on the CDF and LERF. Therefore, there is no change in CDF or LERF being reported for this method." The LAR assumed the adjustment factors to be doubled, vs. increasing by factors of 10 and 100, respectively, to correspond to eliminating the credit altogether. Please describe whether this conclusion applies to the latter case.*

*Related concerns are as follows:*

a. *In PRA-W3-05-005, page 1-6, Appendix I, Summary of Bin 15 Conditional Probabilities, the use of conditional probabilities of 0.1 and 0.01 for SWGR, load centers, motor control centers (MCCs), is a deviation from NUREG/CR-6850 that requires justification or reanalysis via a Methods Sensitivity Evaluation where it is not credited.*
b. *In PRA-W3-05-009, page 27, §2.5.1, Adjustment Factor for Electrical Cabinet Ignition Frequency, the sensitivity analysis, which increases the adjustment factor only two-fold, needs re-evaluation via a methods Sensitivity Evaluation removing this credit entirely, or one based on a fire phenomenological approach consistent with NUREG/CR-6850 that establishes a bounding value that may be <1 for the adjustment factor.*

Waterford 3 Response

An updated analysis (RSC-CALKNX-2012-0825) was performed which removes the reduction factors of 0.1 and 0.01 and re-evaluates the various MCA scenarios to determine if any exceed the screening threshold of 1.00E-7/yr when the UAM is not used. After re-evaluation, 75 scenarios exceeded the screening criterion. The overall impact of the total CDF between the UAM and the approved screening methodology that removes credit for these conditional probabilities shows a CDF increase from 1.35E-6/yr to 3.83E-5/yr. The increase in CDF suggests that further analysis on the potential impacts for multi-compartment fire scenarios is required. The individual and cumulative impacts are included in RAI PRA 40 response.

Related Concern (a):

PRA-W3-05-005 credited conditional probabilities of 0.1 and 0.01 for switchgear, load centers and motor control centers (MCCs) during the screening process for multi-compartment fire scenarios. RSC-CALKNX-2012-0825 removes the credit for the conditional probabilities entirely.

Related Concern (b):

Contrary to the method of doubling the adjustment factor as performed by the sensitivity analysis in PRA-W3-05-009, RSC-CALKNX-2012-0825 removes credit for the conditional probabilities 0.1 and 0.01 entirely and does not introduce any adjustment factor.

RAI PRA 27

*In the Transition Report, pages V-20 and V-21 , §V.2.5, Severity Factor for Pump Oil Fires, the consensus industry-NRC panel did not accept this split in favor of one using 90 percentl10 percent. Subsequently, the NRC questioned the propriety of even this split as well as the estimate of the fraction of applicable spills. Supplement this sensitivity analysis with the 90 percentl10 percent split with one accounting for any additional NRC clarifications related to fire events data to account for in the analysis. Please provide CDF and LERF and ΔCDF and ΔLERF. (See also the entry for Oil Spill in Table 7-1 in PRA-W3-05-006, page 7-2, §7.0, Severity Factor.)*

*Related concerns are as follows:*

a. *In W3F1-2012-0005, page 4 of 7, SO 3, Alternate Method #5: Severe Pump Oil Fire Effects, Item S1-5 in Att. S, Table S-1, Plant Modifications, proposes to install 3M ERFBS in locale RAB 2, et al. Please describe if this was not credited before in the LAR when reporting the risk and delta-risk for the RAB2 scenarios (total = -1.41E-9). Please re-evaluate the results for RAB2 crediting Item S1-5 in light of the NRC clarification of the panel resolution.*
b. *In PRA-W3-05-009, pages 35-40, §2.6, Split Fraction for Pump Oil Severe Fire, the sensitivity analysis compares the Unreviewed Analysis Method split fractions against those from FAQ 08-044, which applies solely to MFWPs. The appropriate Method Sensitivity would compare against the NUREG/CR-6850 split fractions, where the contribution from large and very large fires (0.0196 and 4.00E-4, respectively) are combined into one (very large fires = 0.020). The result would be a change where the severity factor for moderate fires would drop to zero while that for severe fires would rise from 4.0E-4 to 0.020. The effect would appear to be bounded by an increase for the severe fire CDFs by (0.0200.00040)/0.00040 = 49. This would be somewhat offset due to the moving of the moderate fire, with its 0.0196 split fraction and typically lower CCDP (than the severe fire), into the severe fire group. For example, in Table 2.6.2, dominant Scenarios E017, E017M and E017S in RAB2 combined for an original CDF = 8.01E-7. With the appropriate method Sensitivity, the new CDF would be (1.34E-4)(0.506)(0.020) = 1.36E-6, -17 times higher (also -53 percent higher by itself than the total CDF calculated in Table 2.6.2 for all scenarios, 9.04E-7). (See also pages 41-43, §2.7, Split Fraction for DG Room Fire Evaluation.)*

Waterford 3 Response

Both the CDF and LERF increase when reapportioning the split fractions of the severity factors for the pump oil fire scenarios in the reactor auxiliary building (RAB) in favor of the 90 percent / 10 percent split. CDF increases by a factor of 5.43 from 2.56E-6/yr to 1.39E-5/yr while LERF

increases by a factor of 5.89 from 6.28E-8/yr to 3.70E-7/yr. Neither the result from the baseline Waterford 3 fire model nor the reported result following the redistributed split fractions take credit for automatic suppression. When crediting automatic suppression, the CDF decreases from 1.39E-5/yr to 7.03E-7/yr and LERF decreases from 3.70E-7/yr to 1.87E-8/yr. RSC-CALKNX-2012-0821 reports this resolution in greater detail. The individual and cumulative impacts are addressed in RAI PRA 40 response.

Related Concern (a):

The 3M ERFBS fire wrap barrier modification is not a result of fire risk evaluations, but is credited in the fire PRA model for RAB 6 only. The results of the fire risk evaluations did not identify a need to credit 3M ERFBS in RAB 2 in order to meet the acceptance criterion.

Related Concern (b):

RSC-CALKNX-2012-0821 addresses this concern by utilizing the 90 percent / 10 percent split methodology as recommended in RAI PRA 27 response.

RAI PRA 32

*PRA-W3-05-006, page 2-8, §2.2, Assumptions, provides the basis for Assumption 5. For a fire started in a single cable bundle, please discuss whether or not the resulting fires would involve multiple cables in the panel. If so, please describe whether the HRR and other fire effects would be more severe than would be expected for Assumption 5, thereby leading to shorter abandonment times (and higher risk). (See also, page 13-2, §13.1, MCR Analysis; pages 13-4 and 13-5, §13.2.1, MCR Abandonment Times; page 13-21, §13.2.2, MCRAB CCDP Determination)*

Waterford 3 Response

All postulated MCR electrical panel fires involve multiple cables. A single cable bundle fire includes all cables in the bundle (which can include multiple cables in a panel). The single versus multiple bundle classification is one that defines the fuel package. Figures 3-1 and 3-2 (PRA-W3-05-006, Supplement 1) show examples (photographs of electrical cable bundle configuration) of the types of fuel packages.

The two distinct classes of fuel packages (single and multiple bundle) have different heat release rate profiles. Multiple cable bundle fires have higher HRR values and lead to shorter abandonment times (and higher risk) than single cable bundle fires. A variety of tables in PRA-W3-05-008 (Evaluation of the Unit 3 Control Room Abandonment Times at the Waterford Nuclear Station) show this to be true even as a variety of other inputs (i.e. HVAC operation) change.

Though multiple bundle fires events are more severe, applying a 50-50 split between single and multiple bundle fires remains a conservative treatment. Analysis of fire history at nuclear plants indicates this 50-50 split is conservative. A review of Control Room fire events (EPRI FEDB) revealed that none of the fires affected items beyond the point of ignition (no multiple bundle fires).

The Waterford 3 MCR envelope includes several electrical panels, many have a single cable bundle and many have multiple bundles. All of the panels can have a single bundle fire. A multiple bundle fire is only possible in the multiple bundle panels. The spread of a fire from one cable bundle to other cable bundle requires spread beyond the initial fire. There is a high

probability of suppression of such fires in their early stages of development given the continuously manned control room.

RAI PRA 36

*In PRA-W3-05-006, pages 13-4 and 13-6 through 13-20, § 13.2.1, MCR Abandonment Times, both NUREG/CR-6850, Appendix P, and FAQ 08-0050 in Supplement 1 limit the minimum non-suppression probability to 0.001. Zero is not permitted by either reference. The use of zero leads to underestimation of the summed bin frequencies in Tables 13-1 through 13-15 (e.g., an additional [1 -0.008] [0.001] =9.92E-4 would accrue in Table 13-2). Please provide a reanalysis using 0.001 as the minimal NSP. Also, the correspondence between Tables 13-1 through 13-15 and Tables 6-1 through 6-6 in PRA-W3-05-006B, "Evaluation of the Unit 3 Control Room Abandonment Times at the Waterford Nuclear Station," appears to be misaligned in some cases (e.g., 13-2, 13-6, and 13-7 go with 6-2, which is Case 2, not Case 1; 13-8,13-9, 13-10, and 13-11 go with 6-4 (Case 4) or 6-5 (Case 5), not Case 1; 13-13 and 13-14 go with 6-5, which is Case 5, not Case 1; 13-15 goes with 6-5 (Case 5) or 6-6 (Case 6), not Case 1). Please correct the discrepancies.*

Waterford 3 Response

The factors have been updated to be compliant with those present in NUREG/CR-6850 and FAQ 08-0050. The MCR assessment has been reevaluated as a part of PRA RAIs 07 and 22. The revised results and the associated change in CDF and LERF are addressed in the response to RAI PRA 40.

RAI PRA 37

*In PRA-W3-05-006, Appendix F, Beyond 6850 -Supplemental Factor Development, three of the Supplemental Factors presented (Hotwork Alignment, General Transient Alignment and Pump Fires Severity) have been processed through the Unreviewed Analysis Methods consensus industry-NRC panel, with modifications approved to the original proposals provided here. For each of these methods, use of an accepted method needs to be performed and the results provided (noting clarifications provided by the NRC on the latter two). The fourth, EDG Aggressive Fire Factor, has not previously been presented to the consensus panel as an Unreviewed Analysis Method, so remains unresolved as to its validity and proper use at this time. For this method, a Sensitivity Analysis using an accepted method needs to be performed and the results provided.*

Waterford 3 Response

The response to the Hotwork sensitivity is addressed in the response to RAI PRA 25.

General transient analysis is addressed in the response to PRA RAIs 02 and 18.

Pump fire severity is addressed in the response to RAI PRA 27.

The EDG aggressive fire factor is addressed in this response. The baseline analysis utilized a split fraction based on postulated severity of the fires. The larger or so called “aggressive” EDG Fire severity was determined to be 0.217. The smaller less “aggressive EDG fire severity was

then 0.783. These values were used to separate out different scenarios as to the impact of the fire. For the aggressive fire cases, the potential for suppression was addressed as 0.05 for the potential of failure and 0.95 for the potential for success. Three scenarios were defined based on these possible outcomes and identified as 1 (non-aggressive), 1A (aggressive with suppression) and 1B (aggressive without suppression).

The aggressive fire factor was then removed from the analysis and it is assumed that any EDG fire will result in a complete room burn unless the suppression system functions. The severity factor for the non-aggressive scenario is set to zero indicating that no smaller fires are allowed. The potential for suppression remains unchanged.

As documented in RSC-CALKNX-2012-0808, CDF increased from 5.53E-07/yr to 2.53E-06/yr for a delta increase of 1.98E-06/yr. This is due to both a transposition error for one severity factor in the baseline assessment and the removal of the aggressive fire factor.

The aggregate quantitative results are presented in the response to RAI PRA 40.

RAI PRA 40

*In PRA-W3-05-009, pages 44-45, §2.8, Evaluation of Combined Impact, the evaluation results, especially for §2.1 and §2.4 through §2.6, and the resultant combination for all, need to be re-evaluated. Also, an evaluation of the effect from these Sensitivity Analyses on total CDF and ΔCDF and fire LERF and ΔLERF for their plant-wide combination is warranted. The extent to which screening phases of the analyses would be affected by the various sensitivity calculations needs to be addressed. Also, the potential dependence among sensitivity parameters may make it necessary to evaluate some factors together, rather than individually.*

Waterford 3 Response

Section 2.1 – Reduced Heat Release Rate for Transient Scenario Methodology Deviation

A sensitivity study (RSC 12-22) was conducted and involved detailed site walkdown and revision of the transient fire heat release rate (HRR) increasing it from 69 kW utilized in the baseline fire PRA to 317 kW which represents the 98$^{th}$ percentile heat release rate as presented in NUREG/CR-6850 for transient fires. The evaluation associated with 31 PAUs utilized in the fire risk evaluations were revised and new CDF and LERF contributions developed. The study results are indicated in the following table.

| Case | CDF (/yr) | LERF (/yr) |
|---|---|---|
| Baseline Assessment | 1.62E-6 | 2.80E-8 |
| Revised Assessment | 4.64E-6 | 1.11E-7 |
| Change | 3.02E-6 | 8.30E-8 |

More discussions regarding this study can be found in the responses to RAI PRA 02 and RAI PRA 30.

Section 2.4 – Adjustment Factor for Hot Work Ignition Frequency

A sensitivity analysis (RSC-CALKNX-2012-0714) was performed to address the impact on CDF and LERF introduced by removing the adjustment factor of 0.01 from transient fire scenarios for cable tray fires caused by hot work as suggested by an Unreviewed Analysis Methodology (UAM) adopted for the baseline assessment. The study considered each of the 31 PAUs utilized in the fire risk evaluations. The use of the UAM resulted in a negligible contribution from this fire source for the baseline study. The sensitivity study indicates a CDF and LERF contribution increase due to the addition of hot work as shown below.

| Case | CDF (/yr) | LERF (/yr) |
|---|---|---|
| Baseline Assessment | 3.45E-5 | 7.34E-7 |
| Revised Assessment | 3.87E-5 | 8.42E-7 |
| Change | 4.15E-6 | 1.08E-7 |

More discussion regarding this study can be found in the response to RAI PRA 02.

Section 2.5 – Effects on HGL/MCA of Transient Fire Methodology Deviations

There are two issues associated with the section. They involve the screening approach and the associated impacts in terms of subsequent HRR. The impacts are cumulative, but are addressed separately.

Adjustment Factor for Electrical Cabinet Ignition Frequency:

A sensitivity study (RSC-CALKNX-2012-0825) was performed which removes the reduction factors of 0.1 and 0.01 and re-evaluates the various MCA scenarios to determine if any exceed the screening threshold of 1.00E-7/yr when the UAM is not used. The impact of removing the reduction factors for the frequency of cabinet fires increased the CDF for all cabinet scenarios proportionally. As a result, 75 additional scenarios previously screened for analysis now exceed the screening criteria and cannot be excluded from detailed evaluation.

The CDF and the LERF increase as a result of retaining the prior screened out scenarios. The increase is provided in the table below.

| Case | CDF (/yr) | LERF (/yr) |
|---|---|---|
| Baseline Assessment | 1.35E-6 | 1.35E-7 |
| Revised Assessment | 3.96E-5 | 3.96E-6 |
| Change | 3.83E-5 | 3.83E-6 |

More discussion regarding this sensitivity study can be found in the response to RAI PRA 26.

Transient Combustible Heat Release Rate and Transient Adjustment Factors:

Response to RAI PRA 20 states that "the selection of the 702 kW HRR [for HGL screening purposes] is realistic for items such as switchgear or MCC cabinets, and is seen as an appropriate HRR to use as an upper bound to potential cabinet scenario HRRs when evaluating the potential for hot gas layer formation"; this would also serve as an upper bound for a 317 kW transient fire in any room containing electrical cabinets. being evaluated.

Section 2.6 – Split Fraction for Pump Oil Fire Methodology Deviation

For oil fire scenarios, the suggested method by the industry-NRC panel recommend using a split fraction of 0.98 for non-severe oil fire scenarios and 0.02 for severe oil fire scenarios. This approach was used for most oil fire scenarios in the baseline Fire PRA assessment.

A sensitivity study (RSC-CALKNX-2012-0821) compares the results from the baseline approach to results obtained utilizing the suggested split (90/10) from the NUREG/CR-6850 method.

This study reapportions the split fractions used for the non-severe, moderate, and severe pump and HVAC unit oil fire scenarios presented in the baseline model into non-severe and severe categories. This analysis decreases the non-severe severity factors to 0.9 and reapportions the moderate cases into the severe cases for severity factor of 0.1. After reapportioning the severity factors to 0.9 and 0.1 the CDF and LERF initially increased. The results assume no credit for suppression occurs. When suppression is considered for scenarios in RAB 2, the CDF and LERF decreases as shown in the table below.

| Case | CDF (/yr) | LERF (/yr) |
|---|---|---|
| Baseline Assessment | 2.56E-6 | 6.28E-8 |
| Revised Assessment | 7.03E-7 | 1.87E-8 |
| Change | -1.86E-6 | -4.41E-8 |

More discussion regarding this sensitivity study can be found in the response to RAI PRA 27.

Table 1. Combined Increase Due to RAI-Identified Sensitivity Analysis

| Sensitivity Analysis | Net Change in CDF (/yr) | Net Change in LERF (/yr) |
|---|---|---|
| Transient Fire Scenarios (2.1) | 3.02E-6 | 8.3E-8 |
| Hot Work Ignition Frequency (2.4) | 4.15E-6 | 1.08E-7 |
| MCA sensitivity analyses (2.5.1, 2.5.2) | 3.83E-5 | 3.83E-6 |
| Split Fraction for Oil Fires (2.6) | -1.86E-6 | -4.41E-8 |
| Total Increase | 4.36E-5 | 3.98E-6 |
| Baseline Frequency | 3.40E-5 | 7.34E-7 |
| Updated CDF | 7.76E-5 | 4.71E-6 |

The increase in CDF is approximately a factor of two; and approximately a factor of seven in LERF. It is important to note that the MCA contribution is the most significant contributor. This sensitivity study is conservative and retains all scenarios using a CCDP value of 1.0 and CLERP value of 0.1. The contribution from MCA scenarios is expected to decrease as a result of ongoing refinement activities.

The cumulative impacts from all RAIs impacting the FPRA modeling are documented in RSC-CALKNX-2012-0901. The other RAIs that impact the model are discussed below.

RAI PRA 01 - Secondary Ignition Impacts

Secondary ignition was not identified in the baseline Waterford Unit 3 fire PRA. In response to RAI PRA 01, walkdowns of Waterford 3 were performed and locations of plausible secondary ignition targets were recorded. Using insights from this activity and based on physical analysis unit (PAU) specific assessments, secondary ignition targets were identified in only two PAUs which resulted in additional dependent faults due to the expansion of the fire zone of influence provided by the secondary ignition. These PAUs were RAB 8A and RAB 27. The baseline model will be expanded to address these new scenarios.

More discussion regarding this study can be found in the response to RAI PRA 01.

PRA RAIs 07 and 13 - MCR Abandonment HRA Analysis

The baseline FPRA model estimates a value of 0.10 for the CCDP associated with operators shutting down the plant from outside the MCR during a fire induced abandonment scenario. An analysis was completed to calculate the overall probability of the operators unsuccessfully implementing the OP-901-502 procedure; the result from that analysis estimates the conditional probability of failure on the order of 3.87E-1.

There are twelve evacuation scenarios in the baseline fire model. The study shows that the plant-level CDF and LERF increased as shown in the below table.

| Case | CDF (/yr) | LERF (/yr) |
|---|---|---|
| Baseline Assessment | 2.56E-6 | 6.28E-8 |
| Revised Assessment | 7.03E-7 | 1.87E-8 |
| Change | -1.86E-6 | -4.41E-8 |

More discussions regarding this study are found in the responses to RAI PRA 07, RAI PRA 13, and RAI PRA 56 (60 Day RAI Submittal).

RAI PRA 34 – Turbine Building Structural Failure

The baseline FPRA model utilizes a factor of 0.01 for the CCDP associated with response to a turbine building structural failure. Further analysis of the Turbine Generator Building transient fires are included in the CCDP evaluation. The assumption of a bounding CCDP of 0.01 was determined to be non-conservative and a more representative CCDP is 1.06E-01. This value was incorporated into the analysis and the model quantified. The change in CDF and LERF are shown in the table below.

| Case | CDF (/yr) | LERF (/yr) |
|---|---|---|
| Baseline Assessment[1] | - | - |
| Revised Assessment | 3.18E-7 | 2.30E-9 |
| Change | 3.18E-7 | 2.30E-9 |

Note 1. Screened from reported results due to low frequency.

Further discussions regarding this study can be found in the response to RAI PRA 34.

RAI PRA 36 - MCR Abandonment Times - Use of "zero" for non-suppression probability.

The response to this RAI was limited to only those MCR scenarios of interest (11 “CRA” scenarios) that are contained in Tables 13-1 through 13-15 of PRA-W3-05-006. Instituting a minimum probability of failure for the non-suppression factor of 0.001 increases the contribution to the CDF and the LERF for the 11 "CRA" scenarios in the baseline Waterford 3 model as shown in the table below.

| Case | CDF (/yr) | LERF (/yr) |
|---|---|---|
| Baseline Assessment | 1.19E-6 | 1.21E-8 |
| Revised Assessment | 2.11E-6 | 2.14E-8 |
| Change | 9.20E-7 | 9.30E-9 |

Note that this does not affect the NSP factor used for the control room abandonment scenario from PAU RAB 1E. More discussion regarding this sensitivity study can be found in the response to RAI PRA 36.

RAI PRA 37 - EDG Aggressive Fire Factor (other factors discussed in the RAI have been previously discussed).

To determine the impact of the UAM on the results of the EDG diesel fire scenarios, a comparison of the CDF and LERF contributions were performed. This comparison shows that correcting the use of a 0.0783 severity factor versus the 0.783 for non-aggressive fires in the FRANC model has a slight impact on the overall results when the UAM is applied. However, the replacement of the UAM with an approved methodology resulted in an increase in both CDF and LERF as shown in the table below.

| Case | CDF (/yr) | LERF (/yr) |
|---|---|---|
| Baseline Assessment | 5.53E-7 | 1.02E-8 |
| Revised Assessment | 2.53E-6 | 4.67E-8 |
| Change | 1.98E-6 | 3.65E-8 |

More discussion regarding this sensitivity study can be found in the response to RAI PRA 37.

Conclusion from the changes presented above:

Table 2. Cumulative Impacts from all RAIs Impacting the FPRA Model

| Sensitivity Assessment | Net CDF (/yr) Change | Net LERF (/yr) Change |
|---|---|---|
| Transient Fire Scenarios (2.1) | 3.02E-6 | 8.3E-8 |
| Hot Work Ignition Frequency (2.4) | 4.15E-6 | 1.08E-7 |
| MCA sensitivity analyses (2.5.1, 2.5.2) | 3.83E-5 | 3.83E-6 |
| Split Fraction for Oil Fires (2.6) | -1.86E-6 | -4.41E-8 |
| RAI PRA 01 Secondary Ignition[1] | - | - |
| RAI PRA 07 MCR Abandonment Analysis | 4.37E-6 | 4.41E-8 |
| RAI PRA 36 Use of 0.001 as minimum NSF | 9.20E-7 | 9.30E-9 |
| RAI PRA 34 Turbine Building Structural Failure | 3.18E-7 | 2.30E-9 |
| RAI PRA 37 EDG aggressive fire factor | 1.98E-6 | 3.65E-8 |
| Total Increase | 5.12E-5 | 4.07E-6 |
| Baseline Frequency | 3.40E-5 | 7.34E-7 |
| Updated CDF | 8.52E-5 | 4.80E-6 |

1. Resolution of the identified secondary ignition scenarios is an ongoing activity.

RAI PRA 06 - Comparison of Ignition Frequencies from NUREG/CR-6850 versus Supplement 1 to NUREG/CR-6850.

This assessment is not combined in the prior table (Table 1) since it has a dependency on the prior assessments and to add the contribution to CDF and LERF directly in the total in Table 2 would result in overestimation and duplicate impacts. It is provided as a separate sensitivity on the baseline FPRA model.

The baseline WSES3 fire model utilizes data from Supplement 1 to NUREG/CR-6850 and EPRI 1011989 (Reference 1) when calculating CDF and LERF for internal fire scenarios. According to Section 10 of NUREG/CR-6850 (Reference 2), a sensitivity analysis should be performed when using the fire ignition frequencies in EPRI Supplement 1 instead of the fire ignition frequencies provided in Table 6-1 of NUREG/CR-6850.

Examination of the sensitivity results shows that after applying the fire ignition frequencies from NUREG/CR-6850, the resultant CDF and LERF contributions increases as compared to the

CDF and LERF contributions when using the fire ignition frequencies from Supplement 1 to NUREG/CR-6850. The total FPRA CDF and LERF contributions increased as shown in the table below.

| Case | CDF (/yr) | LERF (/yr) |
|---|---|---|
| Baseline Assessment | 3.40E-5 | 7.34E-7 |
| Revised Assessment | 5.93E-5 | 1.26E-6 |
| Change | 2.53E-5 | 9.25E-7 |

More discussion regarding this sensitivity study can be found in the response to RAI PRA 06.

The listed total CDF and LERF represent a conservative estimate for the impact of the method sensitivities and revised scenario selection supporting the response to the RAIs. The cumulative sensitivity summary is within the limits specified by Regulatory Guide 1.174. Incorporating these refinements and the impact of secondary ignition scenarios for RAB 8A and RAB 27 into the baseline analysis is ongoing. Refinements will be integral to the process and the expectation is that these refinements will result in a reduction in the presented CDF and LERF values. The refined model will serve as the baseline assessment for Waterford 3 FPRA.

**SAFE SHUTDOWN ANALYSIS (SSA)**

<u>RAI SSA 07</u>

*Attachment G of the LAR defines the PCS to include the Remote Shutdown Panel Room (LCP-43) and: 1) operation of transfer switches, 2) operation of isolation switches, 3) operation of local control panel switches, 4) operation of power distribution panel switches in the relay or switchgear rooms, 5) manual operation of breakers in the switchgear rooms, and 6) opening of the battery room doors. Attachment G states that Waterford followed the criteria of FAQ 07-0030, Revision 5.*

*The FAQ provides the following criteria for determining whether actions are considered part of the PCS:*

> *...actions that are necessary to activate or switch over to a primary control station(s) may be considered as taking place at primary control station(s) under the following conditions:*
>
> *The actions are limited to those necessary to activate, turn on, power up, transfer control or indication, or otherwise enable the primary control station(s) and make it capable of fulfilling its intended function following a fire. These actions must be related to the alternative/dedicated shutdown function and should take place in locations common to panels that perform the transfer of control. For example, switches that disable equipment in order to allow the alternative/dedicated shutdown location to function would be included as part of the primary control station. However, these actions must be in the same location(s) (panel or the local vicinity surrounding the panel) as the normal/isolation switches and may include de-energization of selected equipment and/or circuits (if such actions are similar to the use of isolation switches). This does not include additional actions in the plant that, while necessary to achieve the NSPC, are not part of enabling the primary control station(s) (e.g., controlling inventory by locally controlling valve(s)).*

*Not all of the PCS actions described in Attachment G appear to be consistent with the guidance of FAQ 07-0030 regarding those actions necessary to enable the primary control station(s). Therefore, the LAR may not identify and quantify the risk of all RAs. For example, opening the battery room doors does not appear to be a required action for enabling the PCS.*

a. *For control room evacuation scenarios; please identify which PCS actions in Table G-1, are associated with enabling the PCS, Panel LCP-43.*
b. *Please provide additional detailed discussion and justification that these actions are necessary to enable the PCS, per the guidance in FAQ 07-0030.*
c. *If any of these PCS actions are determined to be RAs, then Please provide a positive conforming statement that these RAs are feasible and have been evaluated for risk.*

<u>Waterford 3 Response</u>

a) Below are those actions, at a minimum, deemed to be PCS actions as prescribed in FAQ 07-0030. The remaining actions from Attachment G will be evaluated to determine their disposition as PCS actions or as Recovery Actions based on response c).

b) All of the actions in the below table are actions that meet one of the below criteria:

- Action in the Main Control Room
- Action to isolate Main Control Room from Remote Shutdown Panel
- Action to transfer control to the Remote Shutdown Panel
- Action at the Remote Shutdown Panel.

| **Fire Area** | **Equipment ID** | **Equipment Description** | **Action** | **Action Area** |
|---|---|---|---|---|
| RAB1 | *Isolation Switches | ASD Isolation Switches | Place all Fire Isolation Switches in the ISOLATE position at Auxiliary Panel 2B in RAB7B, and Auxiliary Panels 4A and 1B in RAB7A. Operation of these switches will also block any spurious DEFAS-A-AUTO and DEFAS-B-AUTO initiation signals. | RAB7 |
| RAB1 | *MCR Actions | Main Control Room | Prior to exiting the Control Room:<br><br>1. Scram the Reactor<br>2. Close MS-124A and MS-124B<br>3. Place MS-116A and MS-116B in "MANUAL" and close<br>4. Place all Charging Pumps in "OFF"<br>5. Place the Normal Spray Valves in "BOTH"<br>6. Trip the Reactor Coolant Pumps<br>7. Isolate Letdown by closing CVC-101 and CVC-103 | RAB1 |
| RAB1 | *Transfer Switch | ASD Transfer Switches | Operate all transfer switches at Auxiliary Panel 2 in RAB7B, Auxiliary Panel 3 in RAB7D, and Auxiliary Panels 4 and 1 in RAB7A. (Place switches in the AUX CR (transfer) position<br>Operate all transfer switches and push to activate controls at LCP-43 in RAB9. | RAB7, RAB9 |
| RAB1 | CC-MPMP-0001B | COMPONENT COOLING WATER PUMP B | Place CCW Pump B control switch to START at LCP-43. | RAB9 |
| RAB1 | CVC-MPMP-0001B | CHARGING PUMP B | Place Key Switches SS/377, SS/703 and SS/1055 in the ISOLATE position at LCP-80 in RAB3. | RAB3 |

c) RAI PRA 07 (60 Day RAI Submittal) requires the re-evaluation of the main control room abandonment scenarios. An update to the Control Room (RAB1) Fire Risk Evaluation (FRE) is required. Changes to the FRE are impacted by the updated MCR abandonment effort (no longer assuming a 0.1 CCDP), reevaluation and classification of VFDRs, and the changes to credited Recovery Actions. The risk associated with all Recovery Actions will be calculated during the effort to update the risk evaluations. All actions listed in Attachment G have already been evaluated for feasibility and all are feasible. Any additional actions determined to be Recovery Actions as a result of the updated FRE will be evaluated for risk and feasibility.

## FIRE MODELING (FM)

RAI FM 01

*NFPA 805, Section 2.4.3.3, states: "The PSA [probabilistic safety assessment] approach, methods, and data shall be acceptable to the AHJ [authority having authority] ... " The NRC staff noted that fire modeling comprised the following:*

- *The Consolidated Fire Growth and Smoke Transport (CFAST) model was used to calculate control room abandonment times.*
- *The Generic Fire Modeling Treatments approach was used to determine the ZOI in all fire areas throughout plant.*

*Section 4.5.1.2, "FPRA Quality" of the Transition Report states that fire modeling was performed as part of the Fire PRA development (NFPA 805 Section 4.2.4.2). Reference is made to Attachment J, "Fire Modeling V&V," for a discussion of the acceptability of the fire models that were used.*

*Specifically regarding the acceptability of CFAST for the control room abandonment time study:*

a. *Please provide the input files in electronic format for 60 selected CFAST runs that were conducted, i.e., the input files for the cases with the highest HRR in Tables 6-1 through 6-6 in Control Room Abandonment Times Report (Attachment 1 to WSES Fire PRA Fire Scenarios Report, Calculation No. PRA-W3-05-006b).*

b. *Please describe the effect of purge mode ventilation on MCR abandonment.*

c. *During the audit, the NRC staff noted that the ceiling tile thickness in the control room complex is at least 1/2 in. Please explain why a thickness of 1/8-inch was used in the CFAST analysis. Please provide a sensitivity analysis to quantify the effect of using the smaller thickness on control room abandonment times.*

d. *Please provide the basis for the assumption that the fire brigade is expected to arrive within 15 minutes and describe the uncertainty associated with this assumption, discuss possible adverse effects of not meeting this assumption on the results of the FPRA and explain how possible adverse effects will be mitigated.*

e. *Please provide a justification for using average lower bound heat of combustion values and average upper bound yield values (as opposed to the most conservative values) for the cable mix that is present in MCR panels.*

f. *Please provide a gap/sensitivity analysis to demonstrate that the fire growth rates that were used for transient fire scenarios in the control room in lieu of those specified in FAQ-52 lead to more conservative abandonment time estimates or otherwise provide justification for the deviation from the guidelines in FAQ-52.*

g. *During the audit, NRC staff observed numerous combustibles in the equipment area of the control room complex (e.g. a folded table stored between a plastic step stool and moveable stairs, a copier machine and three trash cans close together around a column, etc.). Please provide assurance that the fires involving these combustibles are bounded by the fire scenarios in the equipment area that were considered in the CFAST abandonment time analysis.*

h. *During the audit, NRC staff observed a stack of 18 large plastic containers with personal protective equipment (PPE) (labeled "MSA") in the staff support area of the MCR*

*complex (in the corridor between the control room and HVAC room). Please provide justification for not considering a fire scenario involving these containers in the control room abandonment time study or conduct an analysis to assess the effect of this scenario on the FPRA.*

*i. Please explain how the results of the sensitivity analysis in Appendix B of the Control Room Abandonment Times Report were used in the FPRA.*

*Specifically regarding the acceptability of the Generic Fire Modeling Treatments approach:*

*j. Please explain how the modification to the critical heat flux for a target that is immersed in a thermal plume described in Section 2.4 of the Generic Fire Modeling Treatments document was used in the ZOI determination.*

*k. Please explain how the Generic Fire Modeling Treatments approach was applied for fires against a wall or in a corner, and describe any additional analysis that may have been performed for wall and corner fires. Please identify the fire areas and scenarios where a location factor of 2 (wall fires) or 4 (corner fires) was used and describe the maximum stand-off distance from a wall or corner within which a fire is considered to be against a wall or in a corner.*

*l. Provide technical justification to demonstrate that the Generic Fire Modeling Treatments approach as used to determine the ZOI of fires that involve multiple burning items (e.g., an ignition source and an intervening combustible such as a cable tray) is conservative and bounding.*

*m. Please describe how the flame spread and fire propagation in cable trays and the corresponding HRR of cables was determined. Please explain how the flame spread, fire propagation and HRR estimates affect the ZOI determination and HGL temperature calculations.*

*n. Please describe the purpose of the Generic Fire Modeling Treatments supplements that were used and explain what affect each of the supplements had in the analyses. Additionally, provide a discussion of the appropriateness and the bases for the acceptability of the methods used in the supplements.*

*Regarding the acceptability of the PSA approach, methods, and data in general:*

*o. From the discussion in Section 6.1 of the Fire Scenarios Report (Calculation No. PRA-W3-05-006) it appears that the HRR of transient fires was based on the values in NUREG/CR-6850 for electric motors (98th percentile HRR of 69 kW). It is stated in the Fire Scenarios Report that "the types of transient fires experienced at nuclear power plants were mainly electrical fires." Please provide technical justification for using 69 kW instead of 317 kW for the 98th percentile HRR of transient fires. Please conduct an analysis to quantify the effect of using the higher HRR of 317 kW on the Fire PRA, where the 69 kW cannot be justified.*

*p. The staff is concerned about the possibility that non-cable intervening combustibles were missed in areas of the plant. Please provide information on how intervening combustibles were identified and accounted for in the fire modeling analyses.*

<u>Waterford 3 Response</u>

<u>Part a</u>. The sixty CFAST input files selected during the audit for the Main Control Room Abandonment Calculation (Reference 1) have been provided via electronic mail (Reference 2).

Part b. The smoke purge mode for the MCR is designed for smoke removal after the fire has been suppressed and has a low exhaust rate as compared to the normal HVAC flows in the MCR. Reference 3 provides an assessment of the effect of the smoke purge mode and it is shown that under the most optimistic assumptions the smoke purge mode could reduce the probability of control room abandonment. However, when considering the time required to manually activate the smoke purge mode, it is concluded in Reference 3 that the system is not a significant factor in the control room abandonment times.

Nevertheless, for completeness and conformity with the Section 11.5.2.11 of NUREG/CR-6850 (Reference 4) guidelines for assessing the control room abandonment times, the MCR abandonment calculation has been updated to include a group of fire scenarios that include the smoke purge mode under the most optimistic activation assumptions (Reference 5). Additional discussion is also provided on the flow characteristics and damper alignments when the smoke purge system mode is activated. These new fire scenarios are not used directly in the FPRA but instead provide an indication of the potential benefit in crediting the existing smoke purge system

Part c. A sensitivity assessment of the ceiling tile thickness is provided in Reference 3 for three test cases. The results indicate that increasing the ceiling thickness does not change the results for the two multiple bundle scenarios and only slightly affects the results for the single bundle electrical panel fire scenario considered.

MCR abandonment calculation has been updated in 1JMW21020.000-03, Revision 1 (Reference 5) to reflect the thicker ceiling tile material using the thermal properties for fiberboard.

Part d. A review of the fire brigade drill times for fire brigade arrival in the control room is summarized in Reference 3. It is shown in Reference 3 that the average arrival time is 9 minutes and the maximum response time is 15 minutes for thirty-five drills conducted between October 14, 2011 and August 14, 2012. Although the drill time data indicate the maximum fire brigade arrival time is fifteen minutes, the MCR abandonment calculation has been updated to include a sensitivity assessment on the assumed fire brigade arrival time for completeness (Reference 5).

Part e. A sensitivity assessment of the calculated abandonment times to the variations in the cable composition (assumed combustion properties) is provided in Reference 3. The MCR abandonment calculation (References 1 and 5) uses fuel properties for an equal mix of Neoprene, Ethylene Propylene Rubber (EPR), and Hypalon jacketed cables. The fuel properties for individual cables are determined from the most conservative values for each fuel type. Because the average value is used, different mix fractions could produce an effective fuel with more adverse properties relative to visibility. A set of test cases was used in Reference 3 to assess this potential and it was that a fuel characterize entirely by Neoprene jacketed cables could result in a significant reduction in the predicted abandonment time. However, when viewed in terms of the model bias and model uncertainty, it can be shown that the probability a Neoprene jacketed cable leads to an abandonment time shorter than the baseline case is $7.5 \times 10^{-4}$ or less. In addition, recent cable fuel data provided in NUREG/CR-7010 (Reference 6) indicates that fuel properties obtained from the SFPE Handbook of Fire Protection Engineering, Section 3–4 (Reference 7) may be conservative by a factor of four. The use of the newer properties does not appreciably affect the abandonment times or the probability of control room abandonment. It is therefore concluded that the baseline fuel properties as deduced from an equal mix of Hypalon, EPR, and neoprene cable jacket materials are conservative for this application.

Part f. Reference 3 provides a sensitivity analysis of the predicted control room abandonment times to the assumed growth rate for transient ignition sources. It is shown in Reference 3 that the transient ignition source growth rate assumed in the original MCR abandonment calculation (Reference 1) may be conservative or non-conservative relative to the guidance specified in NUREG/CR-6850, Supplement 1 (Reference 8), depending on the particular NUREG/CR-6850 (Reference 4) heat release rate bin considered. It is further concluded that the predicted abandonment time results are somewhat sensitive to the assumed growth rate, but that the conservatism provided by the assumed abandonment temperature bounds the variation in the predicted abandonment times caused by the non-conservative growth rates (Reference 3). Although the effect of the assumed growth rate is bound by the conservative abandonment criteria assumed, the MCR abandonment calculation has been updated to reflect the recommended transient growth rates in NUREG/CR-6850, Supplement 1 (References 5 and 8).

Part g. The MCR abandonment calculation (Reference 1) postulates both the fifteen bin transient heat release rate fire scenario and rapidly growing plastic pool fire scenarios in the equipment area. The plastic pool fire scenarios are intended to account for the accumulation of transient material that are not readily characterized by the NUREG/CR-6850 (Reference 4) transient heat release rate ignition source. They were included in the MCR abandonment calculation specifically to account for miscellaneous combustible materials identified in this area during the initial survey (Reference 1). The combustibles observed during the original survey consisted of a small and large plastic step stool (movable stairs). Fire scenarios were developed in Hughes Associates, Revision 0 (Reference 1) for each stool as well as for both stools. During the NRC audit, additional combustible materials were observed in this general area, including a folding plastic table between the movable stairs and a proximate photocopier and trash receptacle.

The rapidly growing plastic pool fire scenarios lead to abandonment conditions is less than two minutes for both the large step stool scenario and the scenario with both step stools (Reference 1). Per Figure 3–11 in Hughes Associates, Revision 0 (Reference 1), abandonment is predicted before either fire reaches the calculated peak heat release rate, which means that abandonment is predicted to occur during the growth stage of the fire. Additional mass associated with this fuel package would lead to a larger predicted peak heat release rate, but because the growth rate would remain constant, the predicted abandonment time would not change. Consequently, the rapidly growing plastic pool fire scenarios are broadly applicable to other fuel load configurations and masses due to the short predicted abandonment time.

The fuel package combination that includes the photocopier and the trash container is another fuel package that is not well characterized by the NUREG/CR-6850 (Reference 4) transient test data primarily because of the photocopier. The trash container alone is readily characterized by the NUREG/CR-6850 (Reference 4) transient ignition source, though the growth rate for this item would be eight minutes rather than two minutes as assumed in the revised MCR analysis (Reference 5). Based on the NUREG/CR-6850 (Reference 4) transient test series (NUREG/CR-6850, Table G-7 [Reference 4]), the maximum heat release rate expected from a small to medium sized trash container is on the order of 150 kW (142 Btu/s) or less (References 4 and 5). The heat release rate for a photocopier fire is not easily quantified due to a lack of full scale test data on such commodities; however, the photocopier consists of similar materials and components as computer equipment (computer monitors and desktop towers) for fire test data is available (Reference 9). The peak heat release rate from single computer monitors and desktop towers as reported in the SFPE Handbook of Fire Protection Engineering, Section 3–1 (Reference 9) ranges from 250 – 400 kW (237 – 379 Btu/s) with growth times ranging from three to four minutes. The peak heat release rate from a composite trash container-photocopier fire scenario would thus be ~ 550 kW (521 Btu/s), with the peak heat release rate occurring between three and eight minutes after ignition. This fuel package heat release rate is bound by the rapidly growing plastic fuel package fire in terms of the growth rate and peak fire size. The

peak heat release rate of the combined fuel package is also lower than the point heat release rate for the Bin 15 transient fuel package, which is 578 kW (548 Btu/s) (Reference 3). This means that the transient heat release rate ignition source can be applied to this fuel package combination since the heat release rate range includes the maximum expected heat release rate when full involvement of the fuel package is postulated.

The combustible fuel load in the control room is currently implemented through EN-DC-161, Revision 6 (Reference 10). Fuel loads will be maintained in a configuration that is consistent with the analysis basis in Ref. 5 and other NFPA 805 fire modeling assumptions per LO-WTWF3-2012-00017 (Reference 11).

Part h. Reference 3 provides a sensitivity assessment of the control room abandonment times on various potential fires involving the Self-Contained Breathing Apparatus (SCBA) equipment in the corridor area for a single ventilation configuration. It is found that although the peak heat release rate for the SCBA fuel package could be significantly higher than the workstation fuel package fire evaluated in the computer room, a similar mechanism exists for smoke and energy transport between the support areas and the MCR proper. The analysis of the SCBA polyethylene fires using the test case configuration indicates that the predicted abandonment in the MCR would be greater than twenty-five minutes, the same result reported for the workstation fires (Reference 3).

The SCBA fire scenarios are included in the updated MCR abandonment calculation (Reference 5) as a baseline cases for each HVAC and natural ventilation configuration evaluated for completeness and consistency with the observed fuel loads in the corridor. It is shown in Reference 5 that there are some ventilation configurations in which the abandonment time is shorter than twenty five minutes, the baseline value comparable to the computer room fire scenarios; however, the criterion that triggers abandonment is the conservative 50°C (122°F) immersion temperature threshold in all cases. When viewing the results in terms of the NUREG/CR-6850 (Reference 4) abandonment criteria, abandonment is not predicted in the MCR for either the computer room fire scenario or the polyethylene SCBA fire scenarios in all cases (Reference 3). In addition, the abandonment time for the polyethylene pool fire in the Equipment Area bounds the SCBA fire scenario in all cases.

Part i. The sensitivity analysis results summarized in Appendix B of both Revision 0 and Revision 1 of the control room abandonment report (References 1 and 5) are not directly used in the FPRA. They are provided in the abandonment calculation to identify configurations or assumptions that could affect the calculation results with the intent to either demonstrate conservatism in the baseline cases or to provide an application limit. Reference 3 provides a detailed assessment of each parameter sensitivity study and the baseline scenarios in the updated MCR abandonment calculation (Reference 5) are updated to reflect conservative parameter assumptions per Appendix B of Reference 1.

Part j. Reference 3 provides a detailed description of the use of the modified critical heat flux when determining the ZOI in FPRA fire scenarios using References 12, 13, and 14.

Part k. Reference 3 provides a description of the process for using the ZOI information in References 12, 13, and 14 for wall and corner applications. For the evaluation of transient fire scenarios in response to RAI PRA 02, a series of engineering calculations were developed to analyze the ZOI of transient fire scenarios and their impact to the particular physical analysis unit (PAU) addressed in each calculation file. Each of the transient fire calculations specifies the increase in the transient fire source ZOI from wall and corner effects using the methodology of the transient fire source analysis.

Part l. To ensure that a conservative methodology was used, the “Generic Fire Modeling Treatments” (Reference 11) approach was not used to determine the ZOI of fires that involve multiple burning items (e.g. - secondary ignition). A separate secondary ignition assessment

was performed in response to RAI PRA 01 as documented in RSC-CALKNX-2012-0827 (Reference 14). In this updated analysis, the potential for secondary ignition(s) to occur is evaluated for combustible materials such as cable trays making use of the actual width of the tray(s) in question, transient materials, and electrical cabinets. With regards to secondary ignition of cable trays, this updated analysis follows the guidance of NUREG/CR-6850 (Reference 4) and NUREG/CR-6850, Supplement 1(Reference 8) in terms of characterizing the fire propagation through a vertical cable tray stack and flame spread along cable trays as appropriate for the cable tray configuration of the PAU being analyzed. Where secondary ignition was deemed plausible, the new ZOI from the secondary ignition was determined from the NUREG-1805 (Reference 15) Fire Dynamic Tools (FDTs) spreadsheets. If additional impacts are determined to be present because of a secondary ignition, the additional failures are included in the analysis to evaluate the impact of the additional failures on the PAU.

The transient combustibles fire source ZOI assessment uses the 98$^{th}$ percentile HRR of 317 kW (300 Btu/s) and the assessed electrical cabinet secondary ignition ZOI uses the 98$^{th}$ percentile HRR of 702 kW (665 Btu/s) as found in NUREG/CR-6850 (Reference 4). Cable tray HRR data for secondary ignition(s) is taken from NUREG-1805 (Reference 15) for various plant-specific cable material types with the conservative (higher) value of the cable types being used in the analysis. From the updated secondary ignition analysis, the highest heat release rate from the common thermoset cables types contained within the Waterford Unit 3 is 258 kW/m$^2$ (22.7 Btu/s-ft$^2$) as taken from NUREG-1805 (Reference 15). The use of this heat release rate data is also conservative in comparison to NUREG/CR-7010, Volume 1 (Reference 6) which lists a recommended heat release rate of 150 kW/m$^2$ (13.2 Btu/s-ft$^2$) for typical thermoset cables and a rate of 250 kW/m$^2$ (22 Btu/s-ft$^2$) for typical thermoplastic cables.

<u>Part m</u>. Flame spread follows the guidance of NUREG/CR-6850 (Reference 4) and NUREG/CR-6850, Supplement 1(Reference 8) in terms of characterizing the fire propagation through a vertical cable tray stack and flame spread along cable trays as appropriate for the cable tray configuration of the PAU being analyzed. Fire propagation (secondary ignition) was performed in response to RAI PRA 01 as documented in RSC-CALKNX-2012-0827 (Reference 14) and discussed the response to Part m of this RAI. HGL temperatures were not calculated as part of this initial effort. As forthcoming work progresses, re-analysis of HGL assessments will be completed for areas where secondary ignition is deemed plausible.

<u>Part n</u>. There are five supplements to the original “Generic Fire Modeling Treatments Report 1SPH02902.030, Revision 0 (Reference 11), three of which are used by Waterford 3 FPRA. The three supplements are as follows:

- Supplement 2: “Supplemental Generic Fire Modeling Treatments: Hot Gas Layer Tables” Reference 16);
- Supplement 3: “Supplemental Generic Fire Modeling Treatments: Transient Fuel Package Ignition Source Characteristics” (Reference 12); and
- Supplement 5: “Supplemental Generic Fire Modeling Treatments: Solid State Control Component ZOI and Hot Gas Layer Tables” (Reference 13).

*Supplement 2*. Supplement 2 (Reference 16) was developed to provide additional information that was considered useful when the “Generic Fire Modeling Treatments Report 1SPH02902.030, Revision 0 (Reference 11) was applied. Supplement 2 provides additional hot gas layer tables for transient and electrical panel ignition sources having a time-dependent growth rate and for electrical panel ignition sources with secondary combustible (cable tray) configurations. Hot gas layer tables are also provided for alternate temperature thresholds that correspond to different points on the modified heat flux curve described in 1SPH02902.030, Revision 0 (Reference 11). Finally, ZOI and hot gas layer tables are provided for solid state control components. The secondary combustible hot gas layer tables will be updated for areas

where secondary ignition is deemed plausible as part of forthcoming work. The solid state control component ZOI and hot gas layer results have been superseded by 1JMW21020.000-02, Revision 0 (Reference 13).

The hot gas layer tables and ZOI dimensions for the ignition sources with time-dependent growth rates are calculated using the calculation procedures developed for the original “Generic Fire Modeling Treatments” report (Reference 11) but with different input parameters and solution planes. The basis for the input parameter changes is NUREG/CR-6850 (Reference 4) for the electrical panel growth rate and NUREG/CR-6850, Supplement 1 (Reference 8) for the transient ignition source growth rate. Appendix B of 1SPH02902.030, Revision 0 (Reference 4) documents the generic CFAST fire model approach that is used including the basis for the enclosure, fuel, and ventilation input parameters.

*Supplement 3.* The purpose of Supplement 3 (Reference 12) is to provide a basis for the transient ignition source heat release rate per unit area, fire duration, and flame height. The report uses the transient fire test data referenced in NUREG/CR-6850 (Reference 4) to estimate the transient ignition source characteristics of interest in order to provide a narrower range of input parameters for the ZOI calculations.

1JMW21020.000-01, Revision 1 (Reference 12) is primarily an analysis of test data; however, several revised ZOI tables using the results of the analysis are provided for transient fuel packages in the open, wall, and corner configuration. The ZOI tables determined using the calculation procedures developed for the original “Generic Fire Modeling Treatments” report (Reference 4). The basis for the input parameter changes as well as the application limits are provided by the analysis summarized in 1JMW21020.000-01, Revision 1 (Reference 12). The original “Generic Fire Modeling Treatments Report 1SPH02902.030, Revision 0 (Reference 4) documents the basis for the overall ZOI calculation approach. The wall and corner configurations are assessed using the ‘Image’ method as described in NIST-GCR-90-580 (Reference 17).

*Supplement 5*. Supplement 5 (Reference 13) was developed as part of the response to Probabilistic Risk Assessment RAI PRA 16. The purpose of Supplement 5 (Reference 13) is to provide conservative ZOI and hot gas layer tables for solid state control components. Per NUREG/CR-6850 (Reference 4), these components have a significantly lower temperature and heat flux damage thresholds than either thermoset or thermoplastic cables. The report 1JMW21020.000-02, Revision 0 (Reference 13) develops hot gas layer and ZOI tables for the solid state control components using the damage thresholds recommended in Appendix H of NUREG/CR-6850 (Reference 4) for these components. The same methods used to develop ZOI and hot gas layer tables as documented in 1SPH02902.030, Revision 0 (Reference 4) are applied. The basis for the input parameter changes (performance thresholds) is NUREG/CR-6850 (Reference 4). Application limits for the solid state component ZOI and hot gas layer tables are documented in 1JMW21020.000-02, Revision 0 (Reference 13). The original “Generic Fire Modeling Treatments Report 1SPH02902.030, Revision 0 (Reference 4) documents the basis for the ZOI and hot gas layer calculation approach. The wall and corner configurations are assessed using the ‘Image’ method as described in NIST-GCR-90-580 (Reference 17).

<u>Part o</u>. Efforts are currently ongoing to complete the replacement of the 69 kW (65 Btu/s) transient fire with a 317 kW (300 kW) transient fire. Initial efforts can be seen in the response to PRA RAI 02. Within this response, details regarding the change in methodology when completing transient fire analyses can be found. The impact from the new methodology for 31 PAUs associated with FRE evaluations can be seen in RAI PRA 40.

Part p. Work that supported the response to PRA RAI 01 considered non-cable intervening combustible loads. The initial examination indicates that a potential exists for some scenarios of this type and refinement of the initial examination is underway.

**References**

1. Hughes Associates, Revision 0, “Evaluation of the Unit 3 Control Room Abandonment Times at the Waterford Nuclear Station,” Hughes Associates/Kleinsorg Group Risk Services, Baltimore, MD, March, 2011.
2. Electronic Transmittal of Documentation via email dated October 11, 2012, from Mr. A. Harris to Mr. M. Janssens.
3. 1JMW21020.000-04, Revision 0, “Supplemental Fire Modeling Information in Support of Waterford 3 RAIs,” Hughes Associates/Kleinsorg Group Risk Services, Baltimore, MD, October, 2012.
4. NUREG-6850, “EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities Volume 2 Detailed Methodology,” Electric Power Research Institute (EPRI) 1011989 Final Report, NUREG/CR 6850, Nuclear Regulatory Commission (NRC), Rockville, MD, September, 2005.
5. 1JMW21020.000-03, Revision 1, “Evaluation of the Unit 3 Control Room Abandonment Times at the Waterford Nuclear Station,” Hughes Associates/Kleinsorg Group Risk Services, Baltimore, MD, September, 2012.
6. NUREG/CR-7010, Volume 1 “Cable Heat Release, Ignition, and Spread in Tray Installations During Fire (CHRISTIFIRE) Volume 1: Horizontal Trays,” Final Report for Comment, McGrattan, K., Office of Nuclear Regulatory Research, Nuclear Regulatory Commission, Washington, DC, July, 2012.
7. SFPE Handbook of Fire Protection Engineering, Section 3–4, “Generation of Heat and Chemical Compounds in Fires,” Tewarson, A., *The SFPE Handbook of Fire Protection Engineering*, 4$^{th}$ Edition, P. J. DiNenno, Editor-in-Chief, National Fire Protection Association, Quincy, MA, 2008.
8. NUREG-6850 Supplement 1, “Fire Probabilistic Risk Assessment Methods Enhancements,” EPRI 1019259, NUREG/CR 6850 Supplement 1, Nuclear Regulatory Commission, Washington, DC, September, 2010.
9. SFPE Handbook of Fire Protection Engineering, Section 3–1, “Heat Release Rates,” Babrauskas, V., *The SFPE Handbook of Fire Protection Engineering*, 4$^{th}$ Edition, P. J. DiNenno, Editor-in-Chief, National Fire Protection Association, Quincy, MA, 2008.
10. EN-DC-161, “Control of Combustibles,” Revision 6, Entergy, Killona, LA, January 27, 2012.
11. LO-WTWF3-2012-00017, “Corrective Action General Action Item,” Entergy, Killona, LA, October 2, 2012.
12. 1SPH02902.030, “Generic Fire Modeling Treatments,” Hughes Associates, Revision 0, January 15, 2008.
13. 1JMW21020.000-01, Revision 1, “Supplemental Generic Fire Modeling Treatments: Transient Fuel Package Ignition Source Characteristics,” Hughes Associates/Kleinsorg Group Risk Services, Baltimore, MD, August, 2012.

14. 1JMW21020.000-02, Revision 0, "Supplemental Generic Fire Modeling Treatments: Solid State Control Component ZOI and Hot Gas Layer Tables," Hughes Associates/Kleinsorg Group Risk Services, Baltimore, MD, September, 2012.
15. Pionke, Stephen, Resolution of RAI Based on Secondary Ignition, RSC Engineers, Inc. RSC-CALKNX-2012-0827, Revision 0, September 2012.
16. NUREG-1805, "Fire Dynamics Tools (FDT$^S$)," Iqbal, N. and Salley, M. H., NUREG-1805, Final Report, U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D. C., October, 2004.
17. Hughes Associates, Revision H, "Supplemental Generic Fire Modeling Treatments: Hot Gas Layer Tables," Hughes Associates/Kleinsorg Group Risk Services, Baltimore, MD, July, 2012.
18. NIST-GCR-90-580, "Development of an Instructional Program for Practicing Engineers Hazard I Users," Barnett, J. R. and Beyler, C. L., National Institute of Standards and Technology, Gaithersburg, MD, July, 1990.

RAI FM 02

*NFPA 805, Section 2.5, requires damage thresholds be established to support the performance-based approach. Thermal impact(s) must be considered in determining the potential for thermal damage of structures, systems, or components (SSCs). Appropriate temperature and critical heat flux criteria must be used in the analysis.*

*It is stated in Section 4.1 on page 4-2 of the Fire Scenarios Report that, "Other than the possible use of some thermo-plastic cables for non-safety network/communications wiring all cables are confirmed as thermoset. Consequently the damage thresholds for thermoset cables as specified in NUREG/6850 are used in this evaluation for determination of ZOIs." Please provide the following information:*

a. *Please characterize the installed thermoset and thermoplastic cabling in the power block specifically with regard to the critical damage threshold temperatures and critical heat flux threshold as described in NUREG/CR-6850. Additionally, please provide a statement regarding the extent of installed thermoset cable insulation.*
b. *If thermoplastic cabling is present, discuss the additional targets created/identified using the lower critical temperature damage threshold and/or critical heat flux damage threshold criteria of NUREG/CR-6850. In addition, explain how raceways with a mixture of thermoset and thermoplastic cables were treated in terms of damage thresholds.*
c. *If thermoplastic cabling is present, please discuss impact on ZOI size due to increased HRR and fire propagation.*
d. *If thermoplastic cabling is present, please discuss self-ignited cables and their impact to additional targets created.*
e. *Please explain if and how the effect of holes in closed raceways on the damage thresholds of cables was accounted for.*
f. *If more targets are identified, please describe the impact to CDF and LERF, as well as the ΔCDF and the ΔLERF for those fire areas affected.*

*It is stated in Section 4.2 of the Fire Scenarios Report that "NUREG/CR-6850 recommends failure criteria for solid-state control components of 3 kW/m$^2$ (versus 11 kW/m$^2$ for IEEE qualified cable and 6 kW/m$^2$ for non-IEEE qualified cable) be used for screening purposes.*

*However, given that the enclosure would provide protection to the sensitive internal contents from external fire effects, it is reasonable to apply the same zone of influence established for cable damage. The omission of the credit for the enclosure is judged to offset the non-conservatism of the damage threshold."*

g. *Please provide technical justification for using the damage thresholds for cables to establish the ZOI for solid-state control component targets located inside an enclosure*

Waterford 3 Response

Part a. The damage thresholds for thermoset cables are characterized in "Generic Fire Modeling Treatments", Revision 0 (Reference 1) using either an immersion temperature of 329°C (625°F) or a heat flux of 11.4 kW/m² (1 Btu/s-ft²). The damage thresholds for thermoplastic cables are characterized in Reference 1 using either an immersion temperature of 204°C (400°F) or a heat flux of 5.7 kW/m² (0.5 Btu/s-ft²).

A review of all cable specifications used at the Waterford 3 plant is documented in Reference 2. The review is applicable to cables located both within electrical panels (internal) and outside electrical panels (external). The review concludes that nearly all cables are thermoset and that the Waterford 3 plant should be treated as a thermoset cable plant. In the FPRA, all cables at WSES3 were considered to be thermoset. While nearly all cables at WSES3 are thermoset, findings from independent plant walkdowns did identify the existence of a very limited number of thermoplastic cables. These cables and their locations are listed in Reference 3. Through the transient fire scenarios expansion, critical temperature, critical heat flux, and damage distance (vertical and radial) were determined for thermoset and thermoplastic cables, using data from References 4 and 5. These threshold values are given in Reference 3. From Reference 2, typical thermoset cable insulation material types installed at WSES3 are ethylene propylene rubber (EPR), crosslinked polyethylene (XLPE), clorosulphonated polyethylene (Hypalon), and silicon rubber, which have failure ranges shown in References 1 and 3.

Part b. See response to RAI PRA 15

Part c. See response to RAI PRA 15.

Part d. According to the response to RAI PRA 15, the majority of the thermoplastic cables are located in physical analysis units PAUs where fires are conservatively assumed to result in a complete loss of the PAU, and the cable damage threshold is not a critical parameter due to the assumed whole-room damage. These are located in the turbine building, cable spreading room (RAB 1E), and RAB 27. For other PAUs, the thermoplastic cable population in a specific raceway is between 1 and 5 cables, which is estimated to have a small impact on any existing analyses due to their small loading and, in many cases, the thermoplastic cables that are present are shielded by thermoset cables within the tray which would preclude significant heat up of the thermoplastic cable(s). For the turbine building, cable spreading room and RAB 27, the assessment will be refined as part of forthcoming work. The evaluation will treat the identified cables in a manner consistent with the guidance in NUREG/CR-6850 (Reference 4) assuming a thermoplastic material property.

Additionally, from RAI PRA 15, supplemental walkdowns found that the thermoplastic cables were located primarily in horizontal runs and/or were contained in raceways that were covered. Thus, the potential impact from vertical burning would be limited.

Part e. Holes in closed/sealed raceways were not considered in the FPRA.

Part f. Since thermoplastic cables were not considered in the FPRA, an expansion of the secondary ignition analysis will be necessary for select PAUs as discussed in Part "d" of this RAI response, in order to properly address ZOI, fire propagation, and secondary ignition from

potential thermoplastic cable fires. For those PAUs affected, CDF and LERF values will also be updated as part of forthcoming work.

Part g. The treatment of solid state control components in the FPRA has been revised in response to Probabilistic Risk Assessment RAI PRA 16. The report 1JMW21020.000-02, Revision 0 (Reference 6) was developed to provide conservative ZOI and hot gas layer tables for solid state control components using the NUREG/CR-6850 (Reference 4) recommended critical damage thresholds. Per NUREG/CR-6850 (Reference 4), these components have a damage heat flux exposure of 3 kW/m² (0.26 Btu/s-ft²) and a damage exposure temperature of 65°C (150°F). A modified critical heat flux concept is used in the report 1JMW21020.000-02, Revision 0 (Reference 6) to assess the damage conditions when there is an elevated ambient boundary condition. No credit is taken in the FPRA for the metal enclosure that may surround the solid state control components. In addition, transient response of the solid state control components is ignored. The treatment in the FPRA is thus conservative and consistent with the NUREG/CR-6850 (Reference 4) damage thresholds for screening calculations.

**References**

1. 1SPH02902.030, “Generic Fire Modeling Treatments,” Hughes Associates, Revision 0, January 15, 2008.
2. Becker, D., EC-38344 Reply, Rev. 0, Entergy, 2012.
3. Young, V., Resolution of Fire Modeling RAI 2 - Thermoplastic cable fire impacts, Rev. 0, RSC Engineers Inc., RSC-CALKNX-2012-1001, October 2012.
4. EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities, Volume 1 and 2, Electric Power Research Institute (EPRI) and United States Nuclear Regulatory Commission (USNRC), EPRI 1011989 / NUREG/CR-6850, September, 2005.
5. Miller, J., Documentation of a Transient Fire Source Zone of Influence Using Fire Dynamic Tools (FDTs), Rev.1, RSC Engineers Inc., RSC-CALKNX-2012-0609, September 2012.
6. 1JMW21020.000-02, Revision 0, “Supplemental Generic Fire Modeling Treatments: Solid State Control Component ZOI and Hot Gas Layer Tables,” Hughes Associates/Kleinsorg Group Risk Services, Baltimore, MD, September, 2012.

RAI FM 03

*NFPA 805, Section 2.7.3.2, "Verification and Validation," states: "Each calculational model or numerical method used shall be verified and validated through comparison to test results or comparison to other acceptable models."*

*Section 4.5.1.2, "FPRA Quality" of the Transition Report states that fire modeling was performed as part of the Fire PRA development (NFPA 805 Section 4.2.4.2). Reference is made to Attachment J, "Fire Modeling V&V," for a discussion of the verification and validation (V&V) of the fire models that were used.*

*Furthermore Section 4.7.3, "Compliance with Quality Requirements in Section 2.7.3 of NFPA 805" of the Transition Report states that "Calculational models and numerical methods used in support of compliance with 10 CFR 50.48(c) were verified and validated as required by Section 2.7.3.2 of NFPA 805." Regarding the V&V of fire models:*

a. *Please describe how the empirical equations/correlations in the Generic Fire Modeling Treatments document and supplements were verified (i.e., how was it ensured that the empirical equations/correlations were coded correctly).*

b. *Please describe the V&V of the empirical equations and correlations identified in the supplements to the Generic Fire Modeling Treatments document and provide assurance that these equations/correlations were applied within their appropriate scopes and limitations.*

c. *Please provide technical details to demonstrate that fire models that are not discussed in Attachment J of the LAR, if any, have been applied within the validated range of input parameters, or to justify the application of the model outside the validated range reported in NUREG-1824 or other V&V basis documents*

<u>Waterford 3 Response</u>

<u>Part a</u>. At the time the “Generic Fire Modeling Treatments”, Report 1SPH02902.030, Revision 0 (Ref. 1) report was prepared, a calculation development and review process was used that consisted of a calculation preparer, a calculation reviewer, and a calculation approver. The general responsibilities for each of these elements are as follows:

- The calculation preparer develops and prepares the calculation using appropriate methods.
- The calculation reviewer provides a detailed review of the report and supporting calculations, including spreadsheets and fire model input files. The reviewer provides comments to the preparer for resolution. The reviewer has the option of using an Independent Review, a Design Review, or an Alternate Calculation review method.
- Calculation approver provides a reasonableness review of the report and approves the document for release.

The calculation preparation occurred over a two year period ending in late 2007. The review stage was conducted in late 2007. The calculation was approved January 23, 2008 and signed by the developer, the reviewer, and the approver. The approved document, the signature page, and an affidavit were transmitted to the Document Control Desk at the Nuclear Regulatory Commission in Washington, D. C. on January 23, 2008..

In the case of the empirical equations/correlations that form part of the basis of the “Generic Fire Modeling Treatments” (Ref. 1), a considerable amount of verification was performed during the preparation stage by the preparer. The empirical equations/correlations were solved using Excel® spreadsheets using either direct cell solutions (algebraic manipulation) or Visual Basic macros. All direct cell solutions were validated by the preparer through the use of alternate calculation. For simple equations, this entailed matching spreadsheet solution to the solution obtained using a hand calculator. For more complex solutions, the alternate calculation verification entailed either subdividing the problem into many sub-components and matching the solution using a hand calculator or matching the solution to a verified solution (i.e., the NUREG-1805 (Ref. 2) Solid Flame Heat Flux models). The verification of the Visual Basic macros also depended on the type of macro. In situations where the macro is used to perform multiple direct computations, the macro results were verified against the verified spreadsheet solutions that were verified through alternate calculation. In cases where the macro is used to find a root, the root was verified to be a zero by direct substitution into an alternate form of the solved equation.

The empirical equations/correlations were further verified by the reviewer using a Design Review method as indicated in the signature sheet. An independent reviewer was provided access to the draft report and all supporting calculation materials in late 2007. The reviewer

conducted a detailed review of the implementation of the equations within the spreadsheets and the reporting of the equation result in the draft report. Comments and insights were provided to the preparer over the review period and were addressed to the satisfaction of the reviewer. Upon the completion of the review, a revised draft was prepared for review by the approver about December, 2007. The approver provided a higher level reasonableness check of the methods, approach, and the results. Comments and insights that were provided by the approver were addressed to the satisfaction of the reviewer and Rev. 0 of the report was prepared and approved on January 23, 2008.

Part b. Attachment J to LAR provides the V&V discussion for the fire models applied in Ref. 1. Ref. 3 has been developed in response to this RAI and provides additional V&V discussion for the fire models applied in Ref. 1.

Several applications have been identified in which the results of Ref. 1 have been applied outside the stated limitations of the models as listed in Ref. 1. Ref. 3 has been developed in response to this RAI and provides the technical justification for these applications.

Part c. No additional fire models have been identified as being used in the FPRA directly or indirectly other than those described in the 1SPH02902.030, Revision 0 (Ref. 1); 1JMW21020.000-01, Revision 1 (Ref. 4); 1JMW21020.000-02, Revision 0 (Ref. 5); 1JMW21020.000-03, Revision 0 (Ref. 6); and the response to RAI PRA 01 as documented in RSC-CALKNX-2012-0827 (Ref. 7).

**References**

1. 1SPH02902.030, Revision 0, “Generic Fire Modeling Treatments,” Hughes Associates, January 15, 2008.
2. NUREG-1805, “Fire Dynamics Tools ($FDT^S$),” Iqbal, N. and Salley, M. H., NUREG-1805, Final Report, U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D. C., October, 2004.
3. 1JMW21020.000-04, Revision 0, “Supplemental Fire Modeling Information in Support of Waterford 3 RAIs,” Hughes Associates/Kleinsorg Group Risk Services, Baltimore, MD, October, 2012.
4. 1JMW21020.000-01, Revision 1, “Supplemental Generic Fire Modeling Treatments: Transient Fuel Package Ignition Source Characteristics,” Hughes Associates/Kleinsorg Group Risk Services, Baltimore, MD, August, 2012.
5. 1JMW21020.000-02, Revision 0, “Supplemental Generic Fire Modeling Treatments: Solid State Control Component ZOI and Hot Gas Layer Tables,” Hughes Associates/Kleinsorg Group Risk Services, Baltimore, MD, September, 2012
6. 1JMW21020.000-03, Revision 1, “Evaluation of the Unit 3 Control Room Abandonment Times at the Waterford Nuclear Station,” Hughes Associates/Kleinsorg Group Risk Services, Baltimore, MD, September, 2012.
7. Pionke, Stephen, Resolution of RAI Based on Secondary Ignition, RSC Engineers, Inc. RSC-CALKNX-2012-0827, Revision 0, September 2012.

RAI FM 04

*NFPA 805, Section 2.7.3.3, "Limitations of Use," states: "Acceptable engineering methods and numerical models shall only be used for applications to the extent these methods have been*

*subject to verifications and validation. These engineering methods shall only be applied within the scope, limitations, and assumptions prescribed for that method"*

*Section 4.7.3, "Compliance with Quality Requirements in Section 2.7.3 of NFPA 805," of the Transition Report states that "Engineering methods and numerical models used in support of compliance with 10 CFR 50,48(c) were applied appropriately as required by Section 2.7.3.3 of NFPA 805."*

*Regarding the limitations of use, identify uses, if any, of the Generic Fire Modeling Treatments outside the limits of applicability of the method and for those cases, please justify the use of the Generic Fire Modeling Treatments approach or describe the alternate analysis that was conducted.*

Waterford 3 Response

Attachment J of the LAR provides a detailed list of the range over which the empirical and algebraic models used in the "Generic Fire Modeling Treatments" report 1SPH02902.030, Revision 0 (Reference 1) are applicable. The "Generic Fire Modeling Treatments" report 1SPH02902.030, Revision 0 (Reference 1) incorporates these limitations directly through the compilation of tables under which the empirical model limits are maintained. Several potential applications within the WSES3 FPRA have been identified in which the tabulated data in the "Generic Fire Modeling Treatments" report (Reference 1) are applied outside the specified limits of applicability as listed in Sections 3.2, 4.2, 5.2, 6.2, and Section 7.2 of Reference 1. Reference 2 has been developed in response to this RAI and provides the technical justification for these applications.

**References**

1. 1SPH02902.030, Revision 0, "Generic Fire Modeling Treatments," Hughes Associates, January 15, 2008.
2. 1JMW21020.000-04, Revision 0, "Supplemental Fire Modeling Information in Support of Waterford 3 RAIs," Hughes Associates/Kleinsorg Group Risk Services, Baltimore, MD, October, 2012.

RAI FM 05

*NFPA 805, Section 2.7.3.5, "Uncertainty Analysis," states: "An uncertainty analysis shall be performed to provide reasonable assurance that the performance criteria have been met."*

*Section 4.7.3, "Compliance with Quality Requirements in Section 2.7.3 of NFPA 805," of the Transition Report states that:*

> *"Uncertainty analyses were performed as required by 2.7.3.5 of NFPA 805 and the results were considered in the context of the application. This is of particular interest in fire modeling and Fire PRA development."*

*Regarding the uncertainty analysis for fire modeling:*

a. *Please describe how the uncertainty associated with the fire model input parameters (compartment geometry, radiative fraction, etc.) was accounted for.*
b. *Please describe how the "model" and "completeness" uncertainties were accounted for.*

Waterford 3 Response

Part a. Uncertainty associated with specific fire modeling parameters is addressed through the use of a conservative and bounding analysis. There are three primary areas in which fire modeling parameter uncertainty is applicable:

- The MCR abandonment calculation (References 1 and 2);
- The ZOI tabulations as contained in the "Generic Fire Modeling Treatments" report (Reference 3) and its applicable supplements (References 4 and 5); and
- The hot gas layer tabulations as contained in the "Generic Fire Modeling Treatments" report (Reference 3) and its applicable supplements (References 4 and 5).

Reference 6 has been prepared in response to this RAI and provides a detailed assessment of the parameter uncertainty within each of the three identified areas relative and compares this uncertainty to the conservative bias explicitly introduced in each analysis. It is shown in Reference 6 that the conservative bias associated with the parameter selections, geometric assumptions, and assumed damage thresholds is conservative and bounds the parameter uncertainty as computed using a parameter sensitivity analysis.

Part b. Model and completeness uncertainty associated with the fire modeling applications are addressed through the use of bounding analysis. There are three primary areas in which this type of uncertainty applies:

- The MCR abandonment calculation (References 1 and 2);
- The ZOI tabulations as contained in the "Generic Fire Modeling Treatments" report (Reference 3) and its applicable supplements (References 4 and 5); and
- The hot gas layer tabulations as contained in the "Generic Fire Modeling Treatments" report (Reference 3) and its applicable supplements (References 4 and 5).

Reference 6 has been prepared in response to this RAI and provides a detailed assessment of the model and model completeness uncertainty within each of the three identified areas relative and compares this uncertainty to the conservative bias explicitly introduced in each analysis. It is shown in Reference 6 that the model and completeness uncertainty computed using the methods described in Reference 7 is either bound by the conservative bias associated with the parameter selections, geometric assumptions, and assumed damage thresholds or it would not contribute significantly to the risk uncertainty.

**References**

1. Hughes Associates, Revision 0, "Evaluation of the Unit 3 Control Room Abandonment Times at the Waterford Nuclear Station," Hughes Associates/Kleinsorg Group Risk Services, Baltimore, MD, March, 2011.
2. 1JMW21020.000-03, Revision 1, "Evaluation of the Unit 3 Control Room Abandonment Times at the Waterford Nuclear Station," Hughes Associates/Kleinsorg Group Risk Services, Baltimore, MD, September, 2012.
3. 1SPH02902.030, "Generic Fire Modeling Treatments," Hughes Associates, Revision 0, January 15, 2008.
4. 1JMW21020.000-01, Revision 1, "Supplemental Generic Fire Modeling Treatments: Transient Fuel Package Ignition Source Characteristics," Hughes Associates/Kleinsorg Group Risk Services, Baltimore, MD, August, 2012.

5. 1JMW21020.000-02, Revision 0, “Supplemental Generic Fire Modeling Treatments: Solid State Control Component ZOI and Hot Gas Layer Tables,” Hughes Associates/Kleinsorg Group Risk Services, Baltimore, MD, September, 2012.

6. 1JMW21020.000-04, Revision 0, “Supplemental Fire Modeling Information in Support of Waterford 3 RAIs,” Hughes Associates/Kleinsorg Group Risk Services, Baltimore, MD, October, 2012.

7. NUREG-1934, “Nuclear Power Plant Fire Modeling Application Guide,” Draft for Comment, Salley, M. H. and Kassawara, R. P., NUREG-1934/EPRI-1019195, U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Research, Washington, D. C., 2011.

## RADIOACTIVE RELEASE (RR)

RAI RR 01

*Please provide the specific criteria that were used to "screen out" fire Zones listed as such in Attachment E to the License Amendment Request (LAR).*

Waterford 3 Response

Fire area/zones were screened out based on no reasonable potential for contaminated materials to be stored in these areas during all plant operating modes, including full power to and including non-power conditions.

This meets the goal to have a radiation release to any unrestricted area due to the direct effects of fire suppression activities (but not involving fuel damage) shall be as low as reasonably achievable and shall not exceed applicable 10 CFR, Part 20, Limits.

The screening process considered input from RP personnel and review of the Pre-Fire Strategies.

Based on the review for this RAI, four additional areas associated with pre-fire strategies will be classified as “screened in”. These areas include RAB 22, RAB 23A, TB-001, and TB-002.

Additional details can be found in engineering report RSC 12-23L, “Resolution of W-3 Radioactive Release RAI RR 01 – Screening Criteria for Fire Zones.”

RAI RR 02

*Several Fire Areas are indicated where liquid effluents are collected in sumps or floor drains and routed to holdup tanks. For each such area, please provide a qualitative assessment describing the:*

a. *Capability of sumps and tanks to contain the estimated amount of water to be generated;*
b. *Specific actions/methods (e.g., temporary dikes, absorbent materials, directed fire hose spray) needed to ensure containment of the liquid effluents from this area;*
c. *Additionally, please discuss any pre-planned mitigation actions, procedures, and training.*

Waterford 3 Response

a. Report RSC 12-24L identifies the W-3 fire areas where liquid effluents are collected in sumps or floor drains and are routed to holdup tanks, including the specific drain system associated with each fire area, and any specific actions actions/methods needed to ensure containment of the liquid effluents. This report concludes that the capability of the drain systems is adequate to contain the firefighting liquid effluents.
b. Specific actions to contain fire water introduced as a result of fire fighting efforts are provided in the applicable pre-fire strategy. Because there are drains associated with each area that route the potentially contaminated liquid effluents to a sump or drain system that has the capability to treat contaminated water, no specific actions/methods

were determined to be required to contain the liquid effluents from the areas of interest with the exception of fire area RSB, “Radwaste Solidification Building.” For a fire in this area, doors need to be opened to allow the liquid effluent into the LWM system drains.

c. NTP-202 “Fire Brigade Training Program” provides the fire brigade training sequence to assure the capability to fight potential fires is established and maintained. More details that provide the pre-planned mitigation actions, procedures, and training associated with fighting fires in radiological areas, including the handling of contaminated runoff from the fire are contained in report RSC 12-24L.

RAI RR 03

*Please clarify the method used for "manual ventilation," and provide a qualitative or quantitative assessment of the gaseous releases from such methods for each applicable area that will demonstrate that it meets the acceptance criteria for the Instantaneous Release Technical Specification. Also, for areas where normal ventilation may not be available, include a description of the:*

a. *Type of fire most likely to occur in that fire area (e.g., electrical, transient combustibles);*

b. *Type and amount of radioactive contamination in the fire area;*

c. *Type of fire suppression used in the area (e.g., water, foam, Halon, C02);*

d. *Duration of anticipated fire fighting activities;*

e. *Actions/methods needed to minimize and/or monitor the release of the contaminated gaseous effluent;*

f. *Describe how the Technical Specification limit will be met.*

Waterford 3 Response

Manual ventilation is the use of smoke ejectors to remove smoke from an area after a fire has occurred and normal ventilation is either unavailable or inadequate to remove the smoke. Smoke yield for fires in the RAB and/or FHB areas are not expected to be greater than the capacity of the HEPA filter. Because of little or no contamination in these fire areas, HEPA filters can be bypassed without any impact to unrestricted release of smoke. For areas other than the RAB and FHB, a dispersion analysis was performed and documented in Technical Support Document 12-085 that shows that the gaseous effluent releases from the bounding radiological release fire(s) at WSES-3 meet the Technical Specification acceptance criteria. RSC-CALKNX-2012-0904 identifies the fire areas that have the potential to use smoke ejectors as a backup to normal ventilation, the fire areas that do not have any installed ventilation system in them, and the actions/methods needed to minimize and/or monitor the gaseous effluent releases.

- Questions a, b, c & d: RSC-CALKNX-2012-0904 Table 2 identifies the type(s) of fire most likely to occur in each fire area, the type and amount of radioactive contamination in each area, the type(s) of fire suppression used in each area, and the duration of anticipated fire fighting activities in each area.

- Question e: Actions/methods needed to minimize and/or monitor the release of the contaminated gaseous effluent include:
    - Use of portable smoke ejectors, including air sampling methods when they are in use, and specifying that smoke removal via a pathway that contains a functioning ventilation system is the preferred pathway
    - Air sampling in a smoke-filled environment when smoke ejectors are not in use.

Radiation Protection procedures will incorporate the above actions.

Question f: Bounding scenarios for each waste stream are documented in Technical Support Document 12-085. The results for the most limiting source terms which lead to the highest fraction of the dose limit for gaseous effluents is the LWM Resin in the RSB which results in a release that is 11.6% of the technical specification limits.

RAI RR 04

*Please describe (for areas where drains and/or sumps are not provided) engineered provisions to monitor and contain liquid fire fighting effluent and provide a bounding, quantitative or qualitative analysis that identifies the maximum quantities, forms of radioactive materials in the fire areas, estimates of the effluent concentrations discharged to the unrestricted area, and demonstrates that the instantaneous dose rate limit of the Technical Specifications would be met. Please describe specific methods in the fire pre-plans that will be used to limit or prevent these liquid releases to the unrestricted area (e.g., spill control kits, temporary dikes, storm drain covers, settling ponds etc.).*

Waterford 3 Response

a. RSC-CALKNX-2012-0905 documents five fire areas that do not have drains or sumps associated with them. Engineered provisions such as dikes and the Arpent Canal exist to contain liquid fire fighting effluents. Procedural controls exist to monitor any release from the canal prior to discharge.

b. RSC-CALKNX-2012-0905 provides the information on the fixed contamination levels present in the areas, and the types and maximum quantities of radiological materials that can be stored in each area. Bounding scenarios for each waste stream are documented in Technical Support Document 12-085. The results for the most limiting source terms which lead to the highest fraction of the dose limit for liquid effluents is the DAW stored in the LLWRS which results in a release that is 0.377% of the technical specification instantaneous dose rate limits.

c. The Arpent Canal currently functions similar to a settling pond. Pre-fire strategies will be updated to include additional provisions to limit or prevent a liquid release to the Arpent Canal.

RAI RR 05

*Attachment E states that there are sealed containers of low level radioactive material as well as fixed contamination located in the Yard and Outlying Buildings. Please provide the following details:*

a. *Type of fire most likely to occur in that fire area (e.g., electrical, transient combustibles);*
b. *Type and amount of radioactive contamination in the fire area;*
c. *Type of fire suppression used in the area (e.g., water, foam, Halon, C02);*
d. *Duration of anticipated fire fighting activities;*
e. *Actions/methods needed to minimize and/or monitor the release of the contaminated gaseous effluent;*
f. *Please describe how the Technical Specification limit will be met.*

Waterford 3 Response

The fire areas associated with the Yard and Outlying Buildings include the LLRWSF, CP, RMSB, RSB, YD, and OCA. A dispersion analysis was performed and documented in Technical Support Document 12-085 that shows that the gaseous effluent releases from the bounding radiological release fire(s) at WSES-3 meet the Technical Specification acceptance criteria. RSC-CALKNX-2012-0904 identifies the specifics associated with each of these fire areas.

- Response to questions a, b, c & d include: Table 2 of RSC-CALKNX-2012-0904 Identifies the type(s) of fire most likely to occur in each fire area, the type and amount of radioactive contamination in each area, the type(s) of fire suppression used in each area, and the duration of anticipated fire fighting activities in each area.
- Response to question e: Actions/methods needed to minimize and/or monitor the release of the contaminated gaseous effluent includes air sampling for smoke filled facilities when necessary.

Radiation Protection procedures will incorporate the above actions.

Question f: Bounding scenarios for each waste stream are documented in Technical Support Document 12-085. The results for the most limiting source terms which lead to the highest fraction of the dose limit for gaseous effluents is the LWM Resin in the RSB which results in a release that is 11.6% of the technical specification limits.

RAI RR 06

*Describe if all modes of operations, including non-power operations, have been considered.*

*Attachment E states that there are sealed containers of low level radioactive material as well as fixed contamination located in the Yard and Outlying Buildings. Describe what isotopes will be present and what the activity is.*

Waterford 3 Response

All modes of operation including non-power operations have been considered.

A table is provided in calculation RSC-CALKNX-2012-0906 containing information on the isotopes present in each low level waste stream stored in the sealed containers including the activities associated with each isotope. The characterization data and isotopic information for the DAW, filters, plant resins and LWM resins are taken from the 2011 10 CFR Part 61 report on waste streams at WSES-3. The characterization data and isotopic information for the powdex and B/D resins are taken from the LLRWSF Shielding Calculation. Contaminated oil characterization data and isotopic information are taken from the shipping data associated with the last shipment of contaminated oil from the site.

The radiological surveys used to determine the highest fixed contamination level in each area are contained in Attachment A of calculation RSC-CALKNX-2012-0906.