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W3F1-2015-0015

March 12, 2015

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

SUBJECT: Responses to Request for Additional Information Regarding Adoption of National Fire Protection Association Standard NFPA 805 License Amendment Request (LAR) Waterford Steam Electric Station, Unit 3 (Waterford 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 [ML113220230]

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 [ML12027A049]

3. Entergy letter W3F1-2012-0064 "Response to Request for Additional Information Regarding Adoption of National Fire Protection Association Standard NFPA 805 License Amendment Request, Waterford Steam Electric Station, Unit 3" dated September 27, 2012 [ML12272A099]

4. Entergy letter W3F1-2012-0083 "90 Day Response to Request for Additional Information Regarding Adoption of National Fire Protection Association Standard NFPA 805 License Amendment Request, Waterford Steam Electric Station, Unit 3" dated October 16, 2012 [ML12290A216]

5. Entergy letter W3F1-2013-0022 "Response to 2nd Round Request for Additional Information Regarding Adoption of National Fire Protection Association Standard NFPA 805 License Amendment Request, Waterford Steam Electric Station, Unit 3" dated May 16, 2013 [ML13137A128]

6. Entergy letter W3F1-2013-0048 " Supplement to NFPA 805 License Amendment Request (LAR) Waterford Steam Electric Station, Unit 3" dated December 18, 2013 [ML13365A325]
7. NRC letter to Entergy dated February 6, 2015,"Request for Additional Information RE: License Amendment Request to Transition to National Fire Protection Association Standard 805 (TAC NO. ME7602) [ML15022A239]

Dear Sir or Madam:

By letter dated November 17, 2011, as supplemented by letters dated January 26, September 27, October 16, 2012, May 16, 2013, and December 18, 2013 (References 1 through 6 respectively), Entergy Operations, Inc. (Entergy), submitted a license amendment request (LAR) to transition its fire protection license basis at the Waterford Steam Electric Station, Unit 3, from paragraph 50.48(b) of Title 10 of the *Code of Federal Regulations* (10 CFR) to 10 CFR 50.48(c), "National Fire Protection Association Standard 805" (NFPA 805).

The LAR Supplement provided in Reference 6 represents changes to specified LAR Attachments and supporting calculations primarily as a result of performing extensive reanalysis utilizing only NRC-accepted methods. An NRC site audit was conducted the week of January 12, 2015 followed by Request for Additional Information (RAI) letter (Reference 7) received February 6, 2015. These RAIs were divided into 60, 90 and 120 day responses. Enclosure 1 contains responses to the 60 day RAIs.

There are no new regulatory commitments contained in this submittal.

If you require additional information, please contact the Regulatory Assurance Manager, John Jarrell at 504-739-6685.

I declare under penalty of perjury that the foregoing is true and correct. Executed on March 12, 2015.

Sincerely,

MR Chisum

MRC/ajh

Enclosures: 1. 60 Day RAI Responses
2. Revised Attachment A – NFPA 805 Chapter 3 Requirement 3.11.3

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Enclosure 1 to

W3F1-2015-0015

60 Day RAI Responses
Waterford 3 NFPA 805 License Amendment Request

FPE RAI S01

LAR Attachment A, identifies both “open items” and “confirmatory items” that are necessary to achieve compliance with NFPA 805. In the RAI dated July 18, 2012 (ADAMS Accession No. ML12185A212), FPE RAI 07 had requested the licensee to confirm which “open items” are closed and which should be included as implementation items in the licensee’s LAR application Attachment S. By letter dated September 27, 2012, the licensee responded to FPE RAI 07 and stated that “confirmatory items” are identified as implementation items because these items are solely required for NFPA 805 implementation. The licensee also stated that “open items” are those required for the current Appendix R licensing basis, as well as NFPA 805, and must be corrected regardless of transitioning to NFPA 805. These “open items” are tracked in the plant corrective action program. The licensee further stated that the “open items” are considered as required actions to transfer to NFPA 805, but do not rise to the level of being categorized as “confirmatory items” needing to be listed in Attachment S.

Since the “open items” are required to comply with NFPA 805, and LAR Attachment S is used to document items necessary to complete NFPA 805 implementation, per the proposed licensee condition, provide the following:

a. A revised LAR Attachment S that includes these “open items” as implementation items, or justification for their exclusion.

b. LAR Section 4.1.2.1, “NFPA 805 Chapter 3 Requirements Met or Previously Approved by the NRC,” indicates that the “confirmatory items” and “open items” are associated with the “Complies” compliance statement. However, in the LAR, Attachment A, several of these items are included with elements that state “Complies with use of EEEEs [Existing Engineering Equivalency Evaluations].” For these cases, which include NFPA 805 Chapter 3 Sections: 3.3.1.2(5), 3.3.7.1, 3.4.1(a)(1), 3.5.3, 3.7, 3.8.1, 3.8.2, 3.9.1(1), 3.9.1(2), 3.11.3(2), and 3.11.5, clarify if these “confirmatory items” and “open items” are necessary to comply directly with the NFPA 805 Chapter 3 sections, or if they are associated with the EEEEs that are cited in the compliance basis.

Waterford 3 Response

a. Attachment S is tracking the ‘Open’ items given in Attachment A with the exception of the following NFPA 805 Chapter 3 sections: 3.3.1.2(5), 3.3.5.1, 3.3.10, 3.3.11, 3.3.12(1), 3.5.3-1, 3.7, 3.9.1(1), 3.9.1(2)-1, 3.9.1(2)-3, and 3.11.3(2). All of these ‘Open’ items have been completed with the exception of NFPA 805 Chapter 3 Sections 3.3.5.1 and 3.3.11. These remaining ‘Open’ Items are procedure/document updates being tracked by Attachment S, Item S2-13.

b. These "confirmatory and open items" are necessary to comply directly with the affected NFPA 805 Chapter 3 Section.

FPE RAI S02

90 day response

FPE RAI S03

LAR Attachment A, Section 3.4.1(c) states compliance with NFPA 805 Section 3.4.1(c) which requires that the fire brigade leader and at least two brigade members have sufficient training and knowledge of nuclear safety systems to understand the effects of fire and fire suppressants on nuclear safety performance criteria. In RG 1.189, "Fire Protection for Nuclear Power Plants," Revision 2, dated October 2009 (ADAMS Accession No. ML092580550), Section 1.6.4.1 "Qualifications," the NRC staff acknowledged the following example for the fire brigade leader as sufficient that states, in part:

> The brigade leader should be competent to assess the potential safety consequences of a fire and advise control room personnel. Such competence by the brigade leader may be evidenced by possession of an operator's license or equivalent knowledge of plant systems.

Provide additional detail regarding the training provided to the fire brigade leader and brigade members that addresses their ability to assess the effects of fire and fire suppressants on NFPA 805 nuclear safety performance criteria. Include the justification for how the training meets NFPA 805 Section 3.4.1.

Waterford 3 Response

All Waterford 3 Fire Brigade Members are part of the Operations Department and are Nuclear Auxiliary Operators (NAO). The Fire Brigade Leader and two of the Fire Brigade Members on every Operations Shift are at least Level A NAO's who are qualified on Safety Systems. These Fire Brigade Members are qualified to stand watch in the Reactor Auxiliary Building (RAB) including the Radiation Controlled Area (RCA). As such, they are qualified on all aspects of the operation of every safety system including the potential impact of firefighting activities on those systems. All Level A qualified NAO's are qualified to be Fire Brigade Leaders (FBL) and Hazardous Material (HAZMAT) incident commanders.

Each Fire Brigade Leader and Fire Brigade Member, as qualified Operations watch standers and radiation workers, are physically qualified to stand watch including use of respiratory equipment used during firefighting, HAZMAT and Emergency Planning events.

Fire Brigade Training is provided in accordance with procedure NTP-202, Fire Protection Training, Attachment 7.6 and lesson plan training documents (WLP-FPFB-FFR04, WLP-FPFB-IFB01 and WLP-FPFB-FBL02). This training ensures the Waterford 3 Fire Brigade Leaders and Fire Brigade Members meet the requirements of Regulatory Guide 1.189, Rev. 2, [Section 1.6.4.1, Qualifications] and LAR Attachment A, Section 3.4.1(c). These training documents and the guidance contained within EN-OP-115, Conduct of Operations and OI-042-000, Watch Station Process ensure the Fire Brigade's ability to assess the effects of fire and fire suppressants on the operability of safety related systems. Both the initial and requalification programs for Fire Brigade

Members and Leaders are rigorous accredited programs conducted in compliance with EN-TQ-201, Systematic Approach to Training Process.

The site Fire Brigade training coordinator is a qualified instructor responsible for managing Fire Brigade training and education. This includes:

- Classroom (initial and requalification)
- Fire Field Practical (initial and requalification)
- Conduct of Fire Drills.

FPE RAI S04

NFPA 805 Section 3.4.1(a) requires a minimum fire brigade staff of five persons on duty at all times. LAR Attachment A, the licensee states it complies with clarification that the fire brigade may be less than the minimum complement of five persons for a maximum of 2 hours to accommodate unexpected absences. As described in NEI 04-02, Section 4.3.1, "Complies with Clarification," statements are intended to address compliance differences that are generally editorial in nature. The less-than-minimum staffing statement in the LAR is not considered editorial.

NFPA 805 states that previously approved alternatives to the fundamental fire protection program attributes, identified in Chapter 3, take precedence over the requirements in NFPA 805, Chapter 3.

Clarify whether the NRC has previously approved less-than-minimum fire brigade staffing for Waterford, for this 2-hour grace period, and if so, confirm that this approval has been assessed for "continued applicability and validity." If not, specifically request NRC staff approval of this condition and provide adequate justification.

Waterford 3 Response

The current Waterford 3 Fire Brigade Staffing requirement, including the two hour allowance for less than full staffing, was previously contained in Waterford 3's Technical Specifications (TS) and thus had received commission approval. Amendment 50 to the Waterford 3 Operating License NPF-38, dated 02/07/1989 approved removing this requirement from Technical Specification, to be controlled by the site (currently contained in Operations Procedure OI-042-000, "Watch Station Processes"). The intent of the Fire Brigade Staffing requirements is identical to that previously contained in TS. The need for this exception is unchanged from the original Technical Specification allowance and is consistent with the similar exception for Operations and Radiation Protection Shift staffing currently contained in Technical Specifications Section 6.0, Table 6.2-1, Minimum Shift Crew Composition.

FPE RAI S05

LAR Attachment A, Element 3.11.3(2) refers to LAR Attachment T, for clarification in the Compliance Basis column. In the LAR supplement dated December 18, 2013, the content of LAR Attachment T was reported as “deleted.” Clarify the compliance basis for NFPA 805 Element 3.11.3(2).

Waterford 3 Response

NFPA 805 Element 3.11.3(2) in Attachment A of the LAR Supplement is revised per Enclosure 2. The revision includes the removal of Attachment T as a reference and updates Element 3.11.3(2) to include Attachment K, Deviations 16 and 42, which were omitted in the original LAR Attachment A. Also included in the revision is removal of VFDR 3.11.3 (2) which was closed via EC 39570.

SSA RAI S01

By letter dated December 18, 2013, the LAR supplement provided a revised Attachment S. Clarify or provide a revised status regarding the following Implementation Items:

a. The updated response in the licensee's letter dated June 11, 2014, to RAI SSA 12 states that Implementation Item S2-17 has been revised to ensure that all feasibility criteria in FAQ 07-0030, "Establishing Recovery Actions," are addressed for Nuclear Safety Capability Assessment (NSCA) recovery actions (RAs). The updated response to RAI SSA 08.01, however, states that the only RAs in Attachment G of the revised LAR are associated with tripping Reactor Coolant Pumps, and the RAs were confirmed to be feasible based on all 11 criteria of FAQ 07-0030. From the above RAI responses, it is unclear if all RAs feasibility analysis to FAQ 07-0030 have been completed or if there will be some that are completed during the implementation period. Confirm the time period for the feasibility analyses for Waterford NSCA and non-power operations RAs that are completed and those to be completed per Implementation Item S2-17.

b. Implementation Item S2-20 also involves evaluating a revised list of RAs for feasibility using the criteria of FAQ 07-0030 (see Item a. above) and revising LAR Attachments C, G, S, and W. This implementation item references SSA RAIs 08.01 and 13. However, the licensee's letter dated June 11, 2014, indicates that the actions described in this implementation item have been completed. Clarify the status of which items have been revised and which items remain to be revised per Implementation Item S2-20.

Waterford 3 Response

The status of the LAR Attachment S, Table S-2, Implementation Items S2-17 and S2-20 are identified below:

a. LAR Attachment S, Table S-2, Implementation Item S2-17 action to update the recovery feasibility process against the 11 criteria of FAQ 07-0030 which includes the incorporation of drills into the fire protection program has been completed and is documented in Engineering Report WF3-FP-13-00003, Recovery Action Feasibility & Reliability Review.

b. LAR Attachment S, Table S-2, Implementation Items S2-20 action to evaluate the revised list of Recovery Actions and revise the LAR Attachments C, G, S, and W has been completed. A Recovery Action (RA) is required in four fire areas (RAB 1, RAB 7, RAB 8 and TGB) to trip the Reactor Coolant Pumps (RC-MPMP-0001A, B, 2A & 2B.) The feasibility of the RA in each of the affected Fire Areas using the criteria of FAQ 07-0030 has been performed and is documented in Engineering Report WF3-FP-13-00003, Recovery Action Feasibility & Reliability Review. LAR Attachments C, G, S and W reflect this information.

SSA RAI S02

By letter dated December 18, 2013, the LAR supplement, Attachment C, VFDR 1-045 does not have a disposition. Provide the disposition of this variance from deterministic requirements (VFDR).

Waterford 3 Response

The disposition of VFDR 1-045 in EC-F10-002, WF3 Fire Area RAB-1 Fire Risk Evaluation, is:

This condition was evaluated for compliance using the performance-based approach of NFPA 805, Section 4.2.4. A fire risk evaluation determined that applicable risk, defense-in-depth, and safety margin criteria were satisfied without further action.

SSA RAI S03

By letter dated December 18, 2013, the LAR supplement, Attachment G, the recovery action for RAB 7 references VFDR 7-074. In Attachment C of the LAR supplement, the recovery action for RAB 7 references VFDR 7-070. Confirm which VFDR should be referenced.

Waterford 3 Response

The correct reference in Attachment G for the recovery action for RAB 7 is VFDR-070.

SSA RAI S04

By letter dated December 18, 2013, the LAR supplement, Attachment C, Tables C-1 and C-2, identifies the Fire Suppression and Detection Systems required for compliance by an EEEE or to meet a licensing action. In particular, Fire Areas RAB 15A, RAB 16A, RAB 40 and RAB 41 each reference “Attachment A, Section 3.3.8.” However, the LAR supplement revised a number of Attachment A, Section 3.3.8, compliance statements from “Complies with EEEE” and “Complies by Previous Approval,” to “Complies.” Therefore, in Attachment C, clarify the basis for the required Fire Suppression and Detection Systems to align with Attachment A.

Waterford 3 Response

The Diesel Fuel Oil Tanks in Fire Areas RAB 15A, RAB 16A, RAB 40 and RAB 41 are part of the plant’s diesel supply system. These tanks are inside the power block, however these oil tanks are not for bulk storage and are not applicable to NFPA 805 Section 3.3.8, Bulk Storage.

- For Fire Areas RAB 15A and RAB 16A, the Required Fire Protection Systems and Features Pages (275 and 282) are removed from Enclosure 2 to W3F1-2013-0048 LAR Attachment C Table C-1. The basis for the required Fire Detection and Suppression provided in Attachment C, Table C-2 Pages (5 and 6) is changed from “L” to “NONE”. References to LAR Attachment A, NFPA 805 Section 3.3.8 are removed from this table for these Fire Areas. For Fire Area RAB 15A, the Required Fire Protection Feature Page (5) is changed from “E” to “NONE”.

- For Fire Areas RAB 40 and RAB 41, the Required Fire Protection Systems and Features Pages (421 and 423) are removed from Enclosure 2 to W3F1-2013-0048 LAR Attachment C Table C-1. The basis for the required Fire Suppression provided in Attachment C, Table C-2 Page (11) is changed from "L" to "NONE". References to LAR Attachment A, NFPA 805 Section 3.3.8 are removed from this table for these Fire Areas..

SSA RAI S05

In the LAR, Section 4.8.1 and Attachment C, the licensee designates the basis for requiring a fire protection system or feature as follows: S (Separation), L (Licensing Action), E (EEEE Criteria), R (Risk Criteria), and D (Defense-in-Depth). LAR Attachment C, Table C-2, provides the compilation of required systems and features for all fire areas and follows the Section 4.8.1 designations described above. However, in LAR Attachment C, Table C-1, systems or features required for licensing action or EEEE in individual fire areas are designated "LA/EEEE." Because the LA/EEEE designation in Table C-1 does not follow the same convention as Section 4.8.1 and Table C-2, confirm the designations (i.e., S, L, E, R, D) for the required features and systems in Table C-2 are correct and appropriate for use in determining if the systems and features are required for either a licensing action or an EEEE.

Waterford 3 Response

The software tool utilized to prepare LAR Attachment C-1 only allowed the choice of "EEEE/LA"; if a fire protection feature/system was required for the "Existing Engineering Equivalency Evaluations" and/or "Licensing Actions". However, LAR Attachment C-2 provides further detail by designating the requirement for the specific fire protection feature/system as "E" for "Existing Engineering Equivalency Evaluations" and/or "L" for Licensing Actions" for the applicable fire areas.

SSA RAI S06

By letter dated December 18, 2013, the LAR supplement, Attachment G, states, "Once control of the plant has been established at the primary control station (PCS), operators will use available controls as dictated by operations procedures to maintain the plant in a safe and stable condition. The location of the fire and impact on specific equipment will determine which equipment and actions will be available to the operators." Provide the following clarifications:

a. Clarify whether additional local actions are necessary outside the PCS (i.e., remote shutdown station) to maintain safe and stable conditions once control of the plant has been established at the PCS.

b. If additional actions are necessary to control the plant beyond those performed at the PCS, describe these actions and either: 1) include them in a revised Table G-1 and assess the risk of the additional actions, or 2) provide justification for not including these actions in Table G-1.

Waterford 3 Response

a. There are no additional local actions outside the PCS required to maintain plant safe and stable other than the actions listed in Attachment G.

b. Not Applicable.

FM RAI S01

NFPA 805, Section 2.4.3.3 states that the Probabilistic Risk Assessment (PRA) approach, methods, and data shall be acceptable to the NRC. The NRC staff noted that fire modeling comprised the following:

- The algebraic equations implemented in FDTs [Fire Dynamics Tools] were used to characterize flame radiation (heat flux), flame height, plume temperature, ceiling jet temperature, and hot gas layer (HGL) temperature, the latter of which is used in the multi-compartment analysis.

- The Consolidated Model of Fire Growth and Smoke Transport (CFAST) was used to assess main control room (MCR) habitability and to calculate HGL temperature in selected multi-compartment scenarios.

LAR Section 4.5.1.2, “Fire PRA” states, in part, that “[f]ire modeling was performed as part of the Fire PRA development (NFPA 805 Section 4.2.4.2).” Reference is made to LAR Attachment J, “Fire Modeling V&V [verification and validation],” for a discussion of the acceptability of the fire models that were used.

Regarding the acceptability of the PRA approach, methods, and data:

a. Identify whether any fire modeling tools and methods have been used in the development of the LAR that are not discussed in LAR Attachment J. Conversely, identify any fire modeling tools and methods discussed in LAR Attachment J that have not been used in the fire modeling analyses performed at Waterford.

b. 90 day response

c. 90 day response

d. Typically, during maintenance or measurement activities in the plant, electrical cabinet doors are opened for a certain period of time. Explain what administrative controls are in place to minimize the likelihood of fires involving such an open cabinet, and describe how cabinets with temporarily open doors were treated in the fire modeling analyses.

e. 90 day response

f. For calculation of fixed ignition source ZOIs, the fire area for all cabinet fires was fixed at 0.5 m^2. Justify why using a fixed area is representative of all fixed ignition sources in the plant or demonstrate that the findings from this analysis are not sensitive to the fire area size or that the obtained results are bounding.

   In addition, provide justification for the assumed fire areas and elevations that were used in the transient ZOI calculations. Explain how the model assumptions in terms of location and HRR of transient combustibles in a fire area or zone will not be violated during and post-transition.

g. 90 day response

h. Specifically, regarding the use of CFAST in the MCR abandonment calculations:

  i. 120 day response

  ii. 120 day response

  iii. 90 day response

  iv. Provide the technical basis for the material properties that were specified in CFAST for the transient combustibles in the MCR. Provide confirmation that the assumed soot yield and heat of combustion values are representative of the transient materials that are present in the MCR, or lead to conservative estimates of the soot generation rate.

  v. It appears that the cables in the electrical cabinets are assumed to be an equal mix of ethylene propylene rubber (EPR), Hypalon, and Neoprene. Confirm that this assumption is consistent with the actual cable mixture present in the plant. Provide the technical basis for the material properties that were specified in CFAST for the cables inside the cabinets in the MCR. Provide confirmation that the assumed soot yield and heat of combustion values lead to conservative estimates of the soot generation rate.

i. Specifically, regarding the use of CFAST in the RAB 7A, 7B, 7C and 7D calculations:

  i. 90 day response

  ii. 120 day response

  iii. 90 day response

  iv. Temperature values obtained from the CFAST analysis were used to determine whether a cabinet or sub-PAU [Physical Analysis Unit] fails. Clarify where (location within the surface or volume of the cabinets) these temperature values were recorded and provide the basis for selecting these particular locations.

j. Specifically regarding the multi-compartment analysis (MCA):

  i. Describe the criteria that were used to qualitatively screen multi-compartment scenarios.

  ii. Explain how the methods described in Chapter 2 of NUREG-1805, “Fire Dynamics Tools (FDTs) Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program,” dated December 2004 (ADAMS Accession No. ML043290075) were used in the calculations to screen an ignition source based on insufficient HRR to generate a HGL condition in the exposing compartment.

  iii. Explain how the possibility of damaging hot gases spreading to a third compartment was considered.

Waterford 3 Response

FM RAI S01 a.

Attachment J of the Waterford 3 LAR Supplement (Waterford 3 Letter W3F1-2013-0048) was re-reviewed in response to this RAI, and the only instance of a fire modeling tool or method being used and not presented in Attachment J is the use of NUREG-1805 Fire Dynamics Tools (FDTs) spreadsheet 05.1_Heat_Flux_Calculations_Wind_Free.xls (v. 1805.0) Solid Flame 1 tool which calculates the heat flux at a specific distance from a fire source. This tool and its methods are used in the fire PRA to generate a comparison plot of various heat flux calculational methods in the fixed ignition source and transient ignition source methodology reports PRA-W3-05-006F and PRA-W3-05-013, respectively. This tool is not used in the heat flux level calculations for ignition source zone of influence (ZOI) analyses which uses the Solid Flame 2 tool of the same spreadsheet and is already documented in Attachment J of the Waterford 3 LAR Supplement.

The prediction tool for calculating heat flux at a specific distance from a fire source for wall and corner locations (NUREG-1805 FDTs spreadsheet 05.1_Heat_Flux_Calculations_Wind_Free.xls (v. 1805.0) Point Source Method tool) is listed in Attachment J of the LAR as being used to generate a comparison plot of various heat flux calculational methods. However, this comparison plot is not used in the fixed ignition source or transient ignition source methodology reports PRA-W3-05-006F or PRA-W3-05-013, respectively.

Additionally, hot gas layer (HGL) temperature predictions using the methods of NUREG-1805 FDTs spreadsheets 02.1_Temperature_NV.xls (v. 1805.0), listed in Attachment J of the LAR Supplement as the Method of McCaffrey, Quintiere, and Harkleroad (MQH method) which calculates the HGL temperature in a compartment with natural ventilation (i.e. an open compartment) is listed as a possible tool for use based on physical analysis unit (PAU) arrangements. This FDT is listed as an option for an analyst’s use when a HGL prediction is needed in the methodology for zone of influence (ZOI) determination for the various fixed ignition source bins as presented in PRA-W3-05-006F and for the transient ignition source bin as presented in PRA-W3-05-013. However, this HGL tool is subsequently not used in the Waterford 3 fire PRA analyses of fixed or transient ignition sources.

Similarly, HGL temperature predictions using the methods of NUREG-1805 FDTs spreadsheets 02.2_Temperature_FV.xls (v. 1805.0), listed in Attachment J of the LAR Supplement as the Method of Foote, Pagni, and Alvares (FPA) and the Method of Deal and Beyler, which calculates the HGL temperature in a compartment with forced ventilation is listed as a possible tool for use based on PAU arrangements. This FDT is also listed as an option for an analyst’s use when a HGL prediction is needed in the methodology for zone of influence (ZOI) determination for the various fixed ignition source bins as presented in PRA-W3-05-006F and for the transient ignition source bin as presented in PRA-W3-05-013. However, these HGL tools are subsequently not used in the Waterford 3 fire PRA analyses of fixed or transient ignition sources.

A revised Attachment J of the LAR Supplement will be provided with the 120 day RAI responses.

FM RAI S01 d.

Administrative controls to minimize likelihood of fires involving open cabinets include written procedure guidance in EN-IS-123, Electrical Safety; EN-OP-115, Conduct of Operations; EN-MA-101, Conduct of Maintenance and EN-MA-118, Foreign Material Exclusion and EN-DC-127, Control of Hot Work and Ignition Sources.

Electrical and instrument cabinet doors remain closed at Waterford 3. Procedures require station personnel to ensure equipment doors and covers designed to be closed remain so. Operations procedures require Operations personnel to 1) be alert for any equipment, including electrical and instrument doors, panels and covers, to be in their normal configuration, 2) report any variances from this standard, and 3) correct the deficiency.

Written guidance exists to prevent ignition of fires within electrical and instrument cabinets which must remain open to support work. Any electrical or instrument cabinet which must remain open to conduct work or testing is controlled by procedure or work order. These procedures and work orders include precautions on restricting access to the cabinet interiors by signage and barricading, preventing accumulation of combustible materials near the open cabinet through good work practices and housekeeping, and close out of cabinets to ensure no tools or foreign material remain within the cabinet which might trigger fire ignition.

Any hot work, including hot work within or near open electrical and instrument enclosures, is conducted in accordance with approved procedures and has received required Fire Protection personnel review.

In the fire modeling analyses, all electrical panel (cabinet) doors were treated as closed. Even if a cabinet was found to be sealed (few instances exist), all of the cabinets modeled in the FPRA are conservatively considered vented. The associated heat release rate is based on the presence of thermoset (qualified) or thermoplastic (unqualified) cables with the applicable single or multiple cable bundle characteristic for the particular cabinet being analyzed.

FM RAI S01 f

The zone of influence (ZOI) analyses for each fixed ignition source bin as well as for transient ignition sources are based on the noted 0.5 m^2 fire source area. The methodology and resultant ZOIs for the various fixed ignition source bins are presented in PRA-W3-05-006F . The methodology and resultant ZOI for the transient ignition source bin is presented in PRA-W3-05-013.

As noted in those reports, the fire size (area) is selected for several reasons. First, when heat release rate (HRR) per unit area (HRRPUA) is considered, a fire source must have a HRRPUA greater than 600 kW/m^2 (52.9 Btu/s-ft^2) in order to remain within the NUREG/CR-1824 validation basis fire Froude Number range. Using a fire area of 0.5 m^2 results in a HRRPUA of 300 kW / 0.5 m^2 (or 600 kW/m^2), falling within the validation range of NUREG/CR-1824 for any ignition source bin HRR equal to or greater than 300 kW. Second, FDTs are sensitive to the fire area used and the use of 0.5 m^2 compared to a larger area such as 1.0 m^2 serves to produce more restrictive or conservative (bounding) outputs from the FDTs by predicting higher plume temperatures at the same elevation above the fire source for a smaller fire source area as compared to a larger fire source area. Third, it is a practical size for a cabinet's physical size and expected size of pump motors and other fixed ignition sources being defined for the ZOI analyses.

The fire source area is also a practical size for expected transients with an overall HRR of 317 kW, taken from the 98th percentile HRR from NUREG/CR-6850, such as a trash can or smaller amount of material staged in a plant area. Larger transient fire source areas could be used if they were deemed applicable, though it is likely that a larger area transient fire would not correlate to the overall 317 kW HRR as defined in NUREG/CR-6850.

The transient fire sources are located at the floor level of the particular physical analysis unit (PAU) under consideration as it is representative of the location of materials that would typically be brought into a PAU for temporary work, cleaning, or storage. If curbs, risers, or other elevated areas are present where transient combustibles could possibly be located, analyst judgment is used to locate the fire in the location with the most limiting impacts. However, one characteristic of Waterford 3 is that the presence of such areas is very limited; therefore, instances of such elevated cases are limited as well.

Note that oil source fires, as documented in PRA-W3-05-029 for oil source ZOIs, have a fire source area determined based on the quantity of oil spilled using guidance from NUREG/CR-6850 for a spill depth also based on the quantity of oil spilled.

Transient combustibles during and post-transition will be subject to operational procedures which limit the total amount and locations where potential transients can be within the Waterford 3 plant by procedure EN-DC-161.

FM RAI S01 h.iv

The soot yield, heat of combustion, and carbon dioxide yield for Polyethylene (PE) are based on data provided in Table 3-4.16 of the 4th Edition of the *SFPE Handbook of Fire Protection Engineering*. The soot yield, heat of combustion, and carbon dioxide yield for wood are based on data provided in Table 3-4.16 of the 4th Edition of the *SFPE Handbook of Fire Protection Engineering* for natural materials. Specifically, the properties for the highest soot yield natural material (wood, red oak) are assumed in the CFAST model and are thus conservative for this material type. The heat of combustion used in the CFAST model was increased from the listed value of 12,400 kJ/kg (5,340 Btu/lb) to 13,700 kJ/kg (5,900 Btu/lb) to avoid the lower heat of combustion limit of 13,100 kJ/kg (5,640 Btu/lb) in CFAST, Version 6.1.1. This results in a slightly non-conservative soot mass loss rate since the soot yield was not proportionately increased in the CFAST, Version 6.1.1 model to maintain a constant soot yield to heat of combustion ratio. However, based on Table B-8 in Appendix B of PRA-W3-05-026, Rev. 0, the abandonment times for the transient fire scenarios are not sensitive to variations in the heat of combustion over a range that bounds the CFAST lower limit adjustment and a correction to the assumed soot yield for transient materials is thus not necessary.

Finally, the carbon monoxide (CO) yield for wood listed in Table 3-1 of PRA-W3-05-026, Rev. 0 and used in the CFAST model is 0.0305 kg CO/kg CO_2 produced whereas the value based on Table 3-4.16 of the 4th Edition of the *SFPE Handbook of Fire Protection Engineering* for red oak is 0.00315 kg CO/kg CO_2 produced. The CO yield can have a minor effect on the temperature of the hot gas layer via altering the radiant absorption characteristics of the combustion gases, but otherwise does not affect the predicted abandonment conditions given that toxicity of the modeled environment is not considered. The effect may be conservative or non-conservative, depending on whether visibility or temperature leads to abandonment. Note that the yield properties for wood and PE are reversed in Table 3-1 of the MCR abandonment report (PRA-W3-05-026, Rev. 0), but the averaged properties are used in the CFAST calculations, and these are not affected by the reversed data in Table 3-1 of PRA-W3-05-026, Rev. 0.

The sensitivity analyses provided in PRA-W3-05-026, Rev. 0 will be updated to include sensitivity cases on the assumed CO yield. The updated version of the calculation will be used to complete the response to PRA RAI S04 (120 day response).

It should be also noted that the abandonment times for all baseline fire scenarios are determined using the NUREG/CR-6850 Optical Density (OD) threshold of 3 m^{-1} (0.9 ft^{-1}) (when the hot gas layer height is at or below 1.83 m [6.0 ft]), the NUREG/CR-6850 hot gas layer temperature threshold of 95°C (200°F), or an additional immersion temperature threshold of 50°C (122°F) when the hot gas layer height is at or below 1.83 m (6.0 ft), whichever occurs first. The immersion temperature threshold is significantly more conservative than the NUREG/CR-6850 criteria and in most cases is the limiting abandonment criterion. This introduces a significant conservative bias across all baseline fire scenarios and provides a conservative margin for bounding parameter uncertainty.

FM RAI S01 h.v

The cable mixture for the control room is assumed to be conservative based on input from knowledgeable plant personnel and a review of the content of the more prevalent cable qualification categories which show only one of ten cables containing Neoprene (jacket only).

The sensitivity of the predicted control room abandonment times to the assumed cable mix was evaluated as part of the response to RAI FM 01e (see PRA-W3-05-027, Rev. 0). The most adverse cable mix considered was one represented entirely by the properties of a Cross-Linked Polyethylene (XPLE)/Neoprene cable. It was shown that the predicted control room abandonment times can be sensitive to the assumed cable mix, in particular if the XLPE/Neoprene cable properties are assumed; however, when considering the data for the same types of cables provided in NUREG-7010, Volume 1 and the CFAST tool's uncertainty for visibility predictions, it was concluded that the baseline results as characterized by an equal mix of XLPE/Neoprene, Ethylene Propylene Rubber (EPR), and Hypalon cables are conservative. Because the XPLE/Neoprene cable has the largest soot generation rate, as defined by the ratio of the soot yield to the heat of combustion, among all thermoset cables tabulated in Table 3-4.16 of the *SFPE Handbook of Fire Protection Engineering* (4^{th} Edition), there are no applicable cable fuels that are more adverse than the sensitivity case described in the response to RAI FM 1e (see PRA-W3-05-027, Rev. 0). As such, it is concluded that the baseline abandonment results provided in PRA-W3-05-026, Rev. 0 are conservative with respect to the soot generation rate, or are not significantly sensitive to variations in the actual cable mix in the control room when the fire model uncertainty with respect to the optical density (visibility) parameter is considered.

FM RAI S01 i.iv

The failure criteria were based on predictions taken on the exterior of the upper surface of the panel (cabinet). This location was based on the failure mechanism of interest in the multi-compartment analysis (MCA), as documented in PRA-W3-05-005, of physical analysis unit (PAU) RAB7 where the CFAST analysis, as documented in PRA-W3-05-030, served to investigate the impacts from a potential hot gas layer, which would be expected to form in the ceiling area above the panels (cabinets) and descend to the top of the panels (cabinets), thus impacting the top surface of the panel (cabinet) first. No credit for shielding is taken during the MCA analysis of PAU RAB7 for the predicted temperature values by establishing the panel (cabinet) failure impacts on the outer surface of the panel (cabinet).

FM RAI S01 j.i

Qualitative screenings in the multi-compartment analysis (MCA), as documented in PRA-W3-05-005, are based on the principles of Step 2.c in NUREG/CR-6850 for MCA qualitative screening. Qualitative screening of plant areas is performed before building the compartment adjacency matrix to eliminate those compartments that can be screened as an exposed compartment on the criterion described in NUREG/CR-6850 that the exposed compartment does not contain any PRA-related components and/or cables. In addition, a compartment is qualitatively screened as an exposing compartment if the compartment does not share a common boundary with an exposed compartment that contains PRA related equipment and/or cables.

Several plant areas were qualitatively screened in other fire PRA analyses and are noted in the Plant Partitioning, Qualitative Screening, and Ignition Frequency Development Notebook, as documented in PRA-W3-05-001, due to their lack of PRA-modeled equipment that serve as potential fire scenario target failures. Although these areas can be screened as exposed compartments in the MCA, their potential to be exposing compartments was re- evaluated in the MCA. These areas were reviewed to confirm that their screening from consideration in the MCA is appropriate based on the principles above.

FM RAI S01 j.ii

For hot gas layer (HGL) temperature predictions, Chapter 2 of NUREG-1805 Fire Dynamics Tools (FDTs) spreadsheet 02.3_Temperature_CC.xls (v. 1805.1), which calculates the HGL temperature in a closed compartment given input parameters such as ambient air temperature, ignition source heat release rate (HRR), duration of the fire, and compartment geometry, is used. The use of a closed compartment calculation is a conservative assumption for rooms that may have small ceiling openings.

As stated in PRA-W3-05-005, the following inputs are used for the MCA HGL calculations:

- For most compartments, the floor size is based on an equivalent square of the total surface area of the compartment. Some plant areas reflect unique geometries where a square shape is not used.
- The compartment height is presented with the assumption that the ceiling/floor barrier from one compartment to another is 1.5 ft. thick and is composed of concrete.
- The ambient room temperature for all plant areas is assumed to be 77° F unless otherwise noted.
- The interior lining thickness (or barrier thickness) for walls is assumed to be 12 inches unless otherwise noted. The interior lining material is taken as concrete unless otherwise noted.
- The duration of a fire is limited by either the amount of fuel in the exposing compartment or the postulated time to successful suppression. A time of 25 minutes (1500 seconds) is selected as a conservative value that is representative of both the time to fuel burnout and the confidence of suppression. Oil fire sources, as documented in PRA-W3-05-029, are based on the quantity of oil spilled for burnout duration determination.
- The bounding heat release rates for various fixed and transient ignition sources are provided in NUREG/CR-6850 and use the 98th percentile HRRs for the various ignition source bins. Oil fire sources are based on the quantity of oil spilled for a HRR determination.

The HGL analysis was conducted under the general assumption that the potential for target damage in an exposed compartment occurs when a severe HGL forms in the exposing compartment and propagates to an exposed compartment. If the exposing compartment itself cannot form a sufficiently high HGL temperature, it may be screened from consideration as an impact in the exposed compartment as the combined exposing plus exposed compartment volumes will be larger than only the exposing compartment area and will serve to lower the overall HGL temperature. As an exception to the HGL formation assumption, a unique scenario exists in which a HGL may not form in the exposing compartment, but may form in an adjacent (exposed) compartment due to the smaller relative volume of the adjacent compartment. Essentially, a fire that initiates in the exposing compartment could funnel hot gases into a smaller compartment where the HGL would be more severe than in the original exposing compartment. This unique scenario was considered during the HGL analysis, but no such scenarios were determined to exist.

FM RAI S01 j.iii

Barrier failure from the second to a third compartment was not considered based on guidance from NUREG/CR-6850 that recommends limiting cases to one barrier failure. Additionally, inclusion of an additional barrier failure probability would likely cause any MCA scenario of failure into a third compartment to be screened based on the quantitative screening of retained plant areas in Section 3.3 of PRA-W3-05-005.

FM RAI S02

American Society of Mechanical Engineers/American Nuclear Society (ASME/ANS) Standard RA-Sa-2009, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessments for Nuclear Power Plant Applications," Part 4, requires damage thresholds be established to support the Fire PRA. Thermal impact(s) must be considered in determining the potential for thermal damage of structures, systems, and components and appropriate temperature and critical heat flux criteria must be used in the analysis.

In the updated response by letter dated June 11, 2014, to previous FM RAI 02.a, the licensee stated, in part, "[t]he design specifications for Waterford 3 cables required IEEE [Institute of Electrical and Electronics Engineers]-383 qualification. The materials of construction of the cables are consistent with thermoset performance which was the basis for the determination for the Fire PRA."

However, it appears that a damage threshold of 380 ºCentigrade (C) was used for thermoset cable, as opposed to 330 ºC, which is the NUREG/CR-6850-recommended bounding value for thermoset cable.

a. 120 day response

b. Explain how the damage thresholds for non-cable components (i.e., pumps, valves, electrical cabinets, etc.) were determined. Identify any non-cable components that were assigned damage thresholds different from those for thermoset and thermoplastic cables, and provide a technical justification for these damage thresholds.

c. Explain how exposed temperature-sensitive equipment was treated, and provide the technical justification for the damage criteria that were used.

Waterford 3 Response

FM RAI S02 b.

The majority of active non-cable components such as pumps, valves, and electrical panels (cabinets) have damage thresholds based on the cable type powering the component, with the failure criteria being taken from NUREG/CR-6850 as appropriate for the particular cable type (thermoset or thermoplastic). Thermoplastic cable material is assumed if no other knowledge of the power cable could be determined. For Waterford 3 no selection of thermoplastic cable performance was found to be necessary based on plant information.

Select electrical panels (cabinets) were assigned damage thresholds based on sensitive electronics' failure criteria taken from NUREG/CR-6850 as 65° C for temperature impacts or 3 kW/m^2 for heat flux impacts.

One exception to the NUREG/CR-6850 failure criteria for electrical panels (cabinets) based on sensitive electronics is taken in the multi-compartment analysis (MCA) fire modeling for physical analysis unit (PAU) RAB7 using CFAST as documented in PRA-W3-05-030. In the RAB7 MCA fire modeling, a temperature failure criterion of 60° C rather than 65° C is used based on previously determined failure criteria for the components housed within the electrical panels (cabinets) of PAU RAB7. The heat flux failure criterion of 3 kW/m^2 is also used in PAU RAB7 for the MCA. The scenario impacts of the MCA fire modeling of PAU RAB7 are used to supplement the fire source FDT analyses of PAU RAB7 for quantification in the fire PRA results.

Passive, non-combustible components such as tanks, pipes, and check valves were deemed to not be impacted by potential fire scenarios and as such are not assigned damage thresholds based on guidance in NUREG/CR-6850.

No credit for exposure duration or shielding is taken during the various analyses described above.

The methodology for these damage threshold assignments is presented in PRA-W3-05-006F for use in potential fixed ignition source analyses, in PRA-W3-05-013 for use in potential transient ignition source analyses, and in PRA-W3-05-029 for oil source fire scenarios.

FM RAI S02 c.

Temperature-sensitive equipment (sensitive electronics) at the Waterford 3 plant are typically installed and housed in electrical panels (cabinets) rather than being mounted in an open or exposed location. No instances of directly exposed temperature-sensitive equipment (sensitive electronics) were found in the fire PRA scenario analyses. Most panels (cabinets) installed at the Waterford 3 plant are ventilated and as such no credit is taken for shielding of the enclosed sensitive electronics during fire scenario analyses.

Sensitive electronics as targets in potential fire source analyses are treated with a zone of influence (ZOI) investigation, which is discussed in greater detail in RAI PRA S08.

FM RAI S03

Regarding the V&V of fire models, NFPA 805, Section 2.7.3.2, states that each calculational model or numerical method used shall be verified and validated through comparison to test results or comparison to other acceptable models.

The LAR Section 4.5.1.2 states that fire modeling was performed as part of the Fire PRA development (NFPA 805, Section 4.2.4.2). Reference is made to LAR Attachment J, for a discussion of the V&V of the fire models that were used. Furthermore LAR Section 4.7.3, “Compliance with Quality Requirements in Section 2.7.3 of NFPA 805,” states, in part, 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.”

For any tool or method identified in the response to FM RAI S01.a above, provide the V&V basis if not already explicitly provided in the LAR (for example in LAR Attachment J). Provide technical details to demonstrate that these models were applied within the validated range of input parameters, or justify the application of the model outside the validated range in the V&V basis documents.

Waterford 3 Response

As discussed in RAI FM S01.a, the use of NUREG-1805 Fire Dynamics Tools (FDTs) spreadsheet 05.1_Heat_Flux_Calculations_Wind_Free.xls (v. 1805.0) Solid Flame 1 tool which calculates the heat flux at a specific distance from a fire source is not discussed in Attachment J of the Waterford 3 licensing amendment request (LAR) Supplement (Waterford Letter W3F1-2013-0048). This tool and its methods are used in the fire PRA to generate a comparison plot of various heat flux calculational methods in the fixed ignition source and transient ignition source methodology reports PRA-W3-05-006F and PRA-W3-05-013, respectively.

The V&V basis of the Solid Flame 1 tool is the same as the existing information in Attachment J of the LAR Supplement for the NUREG-1805 FDTs spreadsheet 05.1_Heat_Flux_Calculations_Wind_Free.xls (v. 1805.0) Point Source Method tool which is also used to generate the comparison plot of various heat flux calculational methods in the fixed ignition source and transient ignition source methodology reports PRA-W3-05-006F and PRA-W3-05-013 respectively. The V&V basis from the Point Source Method tool is repeated for the Solid Flame 1 tool.

This is appropriate as the two methods are estimating the same parameter (heat flux) and NUREG-1805 lists the point source method as being the simplest (i.e. more conservative estimate) and the solid flame method being somewhat more refined with both tools being taken from the same originating source, the SFPE Handbook of Fire Protection Engineering, 3rd Edition.

A revised Attachment J of the LAR Supplement will be provided as part of the 120 day RAI responses.

FM RAI S04

a. 120 day response

b. 90 day response.

FM RAI S05

90 day response.

PRA RAI S01

90 day response.

PRA RAI S02

By letter dated June 11, 2014, the response to PRA RAI 04, in which the NRC staff asks about how defense-in-depth was evaluated, did not describe the criteria used to determine when there was a "substantial imbalance between echelons" and did not describe the types of improvements made in response to the evaluation. Also, though the licensee presents criteria used to address safety margin, description of how that criteria was applied to specific parts of Fire Risk Evaluation (FRE) was not provided. Please explain the method used in the FREs to determine when a substantial imbalance between echelons was determined to exist and describe the improvements that were made as a result of the defense-in-depth evaluation. Also provide a description of how criteria used in the FREs to evaluate safety margin criteria was applied to specific elements of the FREs consistent with guidelines/criteria in NEI 04-02.

Waterford 3 Response

This response will address the key elements of PRA RAI S02:

A. Provide defense-in-depth (DID) criteria use to determine when there was a "substantial imbalance between echelons".
B. Describe the method(s) used in the FREs to implement the stated criteria.
C. Describe the types of improvements prescribed as a result of the DID evaluation.
D. Describe how safety margin criteria were applied to specific elements in the FRE process.

(A, B)

The process used for evaluating/considering DID for the Waterford 3 NFPA 805 project is described below. The process was applied to each fire area/fire scenario. DID considerations were part of the FRE process (determining credit and if elements needed to be strengthened to offset weakness) as well as in qualitative DID expert panel evaluations. Balance between the DID echelons is examined in the process. If the criteria for balance is not met (e.g. substantial imbalance between echelons), the process provides guidance to mitigate as much as possible/feasible.

The following methods and criteria for evaluating DID and examples of these improvements are sourced from WF3-FP-13-00004, Rev. 0, "Waterford 3 Defense in Depth Report for NFPA 805" and NEI 04-02 and summarized below:

A review of the impact of the change on DID was performed using the guidance below from NEI 04-02. NFPA 805 defines DID as:

- Preventing fires from starting
- Rapidly detecting fires and controlling and extinguishing promptly those fires that do occur, thereby limiting damage
- Providing adequate level of fire protection for structures, systems and components important to safety; so that a fire that is not promptly extinguished will not prevent essential plant safety functions from being performed.

In general, the DID requirement was considered satisfied if the proposed change does not result in a substantial imbalance among these elements (or echelons). The review of DID was qualitative and addressed each of the elements with respect to the proposed change. Fire protection features and systems relied upon to ensure DID were identified in the assessment (e.g., detection, suppression system).

Consistency with the DID philosophy is maintained if the following acceptance guidelines, or their equivalent, are met:

- A reasonable balance is preserved among 10 CFR 50.48(c) DID elements.
- Over-reliance and increased length of time or risk on performing programmatic activities to compensate for weaknesses in plant design is avoided.
- Pre-fire nuclear safety system redundancy, independence, and diversity are preserved commensurate with the expected frequency and consequences of challenges to the system and uncertainties (e.g., no risk outliers). (This should not be construed to mean that more than one NSCA train must be maintained free of fire damage.)
- Independence of DID elements is not degraded.
- Defenses against human errors are preserved.
- The intent of the General Design Criteria in Appendix A to 10 CFR Part 50 is maintained.

The process for evaluation of DID begins with the risk assessment. The associated fire area risk (CDF) and consequences (CCDP) were reviewed by the site DID expert panel to address general DID echelon imbalances. The following techniques were implemented to mitigate potential imbalance:

- Areas with high ignition frequencies were discussed as areas where additional fire brigade or fire prevention methods may be needed
- Areas with high CCDPs were discussed for additional fire prevention elements.
- Beyond the risk assessment, a discussion of firefighting strategies and operations impacts was performed to determine if additional DID methods could enhance fire brigade response

The following list of items was discussed for each fire area as applicable:

- Review DID echelons for support of specific assumptions in risk evaluations (transient combustible limits, hot work limits, fire barrier considerations).
- Consider CCDP sensitive areas for improvement in fire prevention.
- Develop Operation’s procedure enhancement to improve response to fire scenarios.
- Consider the need for any high-risk, combustible sensitive areas where habitability is limited.
- Consider any active or passive fire protection features retained going forward.
- For high-risk affected areas consider changes to operations procedures considering advanced response or alarm conditions.
    - A review of possible recovery actions not modeled in the PRA was performed using existing strategies to determine if they could provide needed enhancements in DID.
    - This review included a review of the following procedures:
        - OP-901-502---Rev 027---Evacuation of Control Room and Subsequent Plant Shutdown.
        - OP-901-503---Rev 308---Isolation Panel Fire.
        - OP-901-524---Rev 012---Fire in Areas Affecting Safe Shutdown.

- Consider possible modifications that could enhance DID.
    - A review of possible modifications was performed to determine if additional modifications not modeled in PRA could provide needed enhancements in DID.
- Review of possible DID enhancements based on the 92-18 valves found to be modeled in the PRA inconsistent with their NSCA function.

(C)

Examples of DID enhancements include, but not limited to the following: Hot work and combustible control enhancements, requiring suppression and/or detection to meet DID criteria, installation of radiant fire barriers, etc. These examples are derived from panel discussions as documented in the FRE and DID source reference(s). The primary enhancements chosen as a result of this review were hot work and combustible control enhancements and credit for partial height walls.

Table 1 (next page) was used to aid in the consistency of the review of DID.

Table 1 - Considerations for Defense-in-Depth Determination

Method of Providing DID	Considerations
Echelon 1: Prevent fires from starting	
▪ Combustible Control ▪ Hot Work Control	Combustible and hot work controls are fundamental elements of DID and as such are always in place. The issue to be considered during the FREs is whether this element needs to be strengthened to offset a weakness in another echelon thereby providing a reasonable balance. Considerations include: ▪ Creating a new Transient Free Areas ▪ Modifying an existing Transient Free Area The fire scenarios involved in the FRE quantitative calculation should be reviewed to determine if additional controls should be added. Review the remaining elements of DID to ensure an over-reliance is not placed on programmatic activities to compensate for weaknesses on plant design.
Echelon 2: Rapidly detect, control and extinguish promptly those fires that do occur thereby limiting fire damage	
▪ Detection system ▪ Automatic fire suppression ▪ Portable fire extinguishers provided for the area ▪ Hose stations and hydrants provided for the area ▪ Fire Pre-Fire Plan	Automatic suppression and detection may or may not exist in the Fire Area of concern. The issue to be considered during the FRE is whether installed suppression and or detection is required for DID or whether suppression/detection needs to be strengthened to offset a weakness in another echelon thereby providing a reasonable balance. Considerations include: ▪ If a Fire Area contains both suppression and detection and firefighting activities would be challenging, both detection and suppression may be required ▪ If a Fire Area contains both suppression and detection and firefighting activities would not be challenging, require detection and manual firefighting (consider enhancing the pre-plans) ▪ If a Fire Area contains detection and a recovery action is required, the detection system may be required. ▪ If a Fire Area contains neither suppression nor detection and a recovery action is required, consider adding detection or suppression. The fire scenarios involved in the FRE quantitative calculation should be reviewed to determine the types of fires and reliance on suppression should be evaluated in the area to best determine options for this element of DID.

Echelon 3: Provide adequate level of fire protection for systems and structures so that a fire will not prevent essential safety functions from being performed	
▪ Walls, floors ceilings and structural elements are rated or have been evaluated as adequate for the hazard. ▪ Penetrations in the Fire Area barrier are rated or have been evaluated as adequate for the hazard. ▪ Supplemental barriers (e.g., ERFBS, cable tray covers, combustible liquid dikes/drains, etc.) ▪ Fire rated cable ▪ Reactor coolant pump oil collection system (as applicable) ▪ Guidance provided to operations personnel detailing the required success path(s) including recovery actions to achieve nuclear safety performance criteria.	If fires occur and they are not rapidly detected and promptly extinguished, the third echelon of DID would be relied upon. The issue to be considered during the FRE is whether existing separation is adequate or whether additional measures (e.g., supplemental barriers, fire rated cable, or recovery actions) are required offset a weakness in another echelon thereby providing a reasonable balance. Considerations include: ▪ If the VFDR is never affected in the same fire scenario, internal Fire Area separation may be adequate and no additional reliance on recovery actions is necessary. ▪ If the VFDR is affected in the same fire scenario, internal Fire Area separation may not be adequate and reliance on a recovery action may be necessary. ▪ If the consequence associated with the VFDRs is high regardless of whether it is in the same scenario, a recovery action and / or reliance on supplemental barriers should be considered. ▪ There are known modeling differences between a Fire PRA and nuclear safety capability assessment due to different success criteria, end states, etc. Although a VFDR may be associated with a function that is not considered a significant contribution to CDF, the VFDR may be considered important enough to the NSCA to retain as a recovery action. The fire scenarios involved in the FRE quantitative calculation should be reviewed to determine the fires evaluated and the consequence in the area to best determine options for this element of DID.

(D)

The fire risk evaluation incorporated the re-examination of plant system performance given the specific demands associated with postulated fire events (by means of the analytical fire PRA model and qualitative DID panel). The methods, input parameters, and acceptance criteria used in these analyses have been reviewed against that used for the plant design basis events. This is the process by which the safety margin inherent in the analyses for the plant design basis events have been preserved in the analysis for the fire event.

An example of a practical application of maintaining safety margin is the evaluation of compensatory measures that provide an equivalent level of protection of a suppression system being impaired. This example would be identified and evaluated in the FRE process and consideration of equivalency (or not) provides the basis of adequately evaluating and maintaining safety margin. Each FRE provides the specific details of how safety margins are maintained for each fire area. For example, the Waterford 3 FRE for RAB 1 (EC-F10-002) lists four specific areas where safety margins are maintained; fire modeling, plant system performance, PRA logic model, and success path confirmation.

PRA RAI S03

120 day response.

PRA RAI S04

120 day response.

PRA RAI S05

By letter dated June 11, 2014, the response to PRA RAI 08 explains that Attachment W of the LAR was entirely revised as part of the LAR supplement, and that calculation of ΔCDF and ΔLERF is discussed in the updated Section W.2.1 of the LAR. The discussion in the updated Section W.2.1 of the LAR primarily references an internal Waterford document instead of providing the requested description of the calculations for ΔCDF and ΔLERF used at Waterford.

The response to PRA RAI 57a is also related to the calculation of ΔCDF and ΔLERF because it states, in part, "LAR Supplement Attachment C (Table B-3) provides detailed dispositions for non-modeled VFDRs." The NRC staff reviewed the updated Attachment C of the LAR and notes that in 187 instances VFDR dispositions state: "[t]his condition has no corresponding PRA basic event and by definition has insignificant risk" and references an internal Waterford document. Review of the referenced internal Waterford document indicates that some component failure modes were selected for exclusion from the PRA (e.g., control indication, component cooling water makeup to emergency diesel generators, HVAC and Feed Tank level), but the rationale and justification for exclusion is not always clear. Provide the following information:

a. Summary of the model adjustments made to remove VFDRs from the compliant plant model, such as adding events or logic, or use of surrogate events.

b. Identify any risk-reduction modifications credited in the change-in-risk calculations and explain how these are included in the post-transition and compliant plant models.

c. Discussion of the rationale used for excluding VFDRs from the calculation of ΔCDF and ΔLERF. Include justification of why so many VFDRs were excluded from the change-in-risk calculations.

d. Summary of how the change in risk was determined for MCR abandonment scenarios, including a summary of how the CCDP was determined for the compliant and for the variant plant models.

e. Provide separately the total risk increase associated with retained VFDRs and the total risk decrease associated with risk reduction modifications.

Waterford 3 Response

A) The baseline fire PRA represents the non-compliant plant since it addresses the impact of the VFDRs on plant components. To derive the compliant plant model, the non-compliant plant is adjusted to represent a condition where the VFDR no longer exists in the specific PAU. In some cases, this required additional logic to address spurious impacts that were not considered as plausible in the original fire PRA model.

To simulate the compliant condition, the impacts to the source of the VFDR were removed from the PAU cable and component impact listing such that components associated with the VFDR were not failed by any fire in the PAU. This results in no contribution to the CDF or LERF results from the source of the VFDR and a compliant plant is represented. For example, if a specific VFDR addressed a power cable to a valve that was present in a specific PAU, the non-compliant case would assume a fire could potentially fail the cable and the valve would be failed due to a loss of power. For the compliant plant the cable is excluded (removed) from the PAU inventory such that a fire cannot fail that specific cable and the valve will not be failed by a fire in that PAU.

B) The risk reduction modifications (plant modifications, recovery actions and program changes) are described in PSA-WF3-03-02, "Waterford Steam Electric Station 3 Summary of Fire PRA Driven Plant Improvements to Waterford 3 to Support Risk Optimization" are summarized below:

- Removal of secondary combustible material from RAB 27. This involved the removal of combustible materials from RAB 27 to preclude fire growth due to secondary ignition.
- Inclusion of local manual trip of reactor coolant pumps given a loss of remote trip switch function. This involves locally tripping power for the reactor coolant pumps from the turbine building switchgear for scenarios where the main control board switches may not be available due to fire induced effects.
- Inclusion of ERFBS wrap in RAB 6. The walkdown confirmed the existence of the ERFBS wrap in RAB 6. Therefore, the fire PRA included it as an "as found" condition.
- An implementation item (S2-21) was added to update plant procedures to satisfy the FPRA credited mission times for Nitrogen Accumulators.

These four risk reduction modifications were assumed to be installed when the VFDRs were quantified for both post-transition and compliant plant models. By their inclusion the risk reduction obtained by addressing VFDRs is captured and not masked by the risk reductions of these modifications.

C). PSA-WF3-03-01,"Waterford Steam Electric Station 3 Methodology for Addressing VFDRs in the Fire PRA and NFPA-805, November 2013" provides a detailed evaluation of each VFDR. In some cases the component associated with the VFDR is not contained in the fire PRA model. This is typically due to differences in the deterministic requirements and the PRA success criteria boundary conditions. All VFDRs that would impact the risk model (component included in the model) were addressed in the FRE calculations. Additionally, if the failure would impact the PRA model and should be included, it was added to the model to reflect the postulated failure modes. The remaining VFDRs have no impact on the PRA model and were screened using one of several documented criteria. A VFDR was excluded from the fire risk evaluation calculation if it met any of the following:

<u>Disposition 1: Excluded based on Refined Room Cooling Assessment</u>

The internal events PRA model serves as the starting point for the fire PRA and the system success criteria are derived from information contained in PSA-WF3-01-SC. The internal events PRA was updated in March 2013. One area updated was the room cooling requirements.

The internal events system notebook (PSA-WF3-01-SY) indicates that the steady state peak temperature following a loss of HVAC is below the realistic failure temperatures for equipment in the safeguards, CCW pump, CCW heat exchanger, charging pump, battery, +46 foot heating and ventilation equipment, control room HVAC equipment room, EFW pump, and electrical switchgear rooms. The loss of HVAC to any of these rooms would not result in component failure in 24 hours. The fault tree logic for these HVAC models was removed in Revision 5 of the Waterford 3 internal events model (PSA-WF3-01-QU) and there is no longer any basic event to be associated with the cable fault.

<u>Disposition 2: Excluded based on PRA Success Criterion</u>

PSA-WF3-01-SC provides the basis for the internal events PRA and therefore the fire PRA. It defines the minimum equipment and systems necessary to maintain a safe stable state and no core damage. This must be maintained for a period of 24 hours. In some cases this includes specific equipment that is useful in regard to safe and stable, but is not strictly necessary for successful shutdown operation. This includes makeup to systems which have been shown to have adequate inventory to function for 24 hours. More specific descriptions for the use of Disposition 2 in excluding VFDR components are provided below.

Disposition 2a: BAM ILT 206 and BAM ILT 208 Boron Acid Makeup Tank Level Sensor

Level sensors BAM ILT 206 and BAM ILT 208 are associated with the Boric Acid Makeup Tank which is only required for an Anticipated Transient Without Scram (ATWS) event in the Waterford 3 internal events PRA. NUREG/CR-6850 allows exclusion for sequences associated with events that a low-frequency argument can be justified. In the provided example, the text states on page 2-7 that:

"it can often be easily demonstrated that anticipated transient without scram (ATWS) sequences do not need to be treated in the Fire PRA because fire-induced failures will almost certainly remove power from the control rods (resulting in a trip), rather than cause a "failure-to-scram" condition. Additionally, fire frequencies multiplied by the independent failure-to-scram probability can usually be argued to be small contributors to fire risk due to the associated low frequency of core damage and LERF scenarios."

On this basis the level transmitters are excluded from the fire PRA.

Disposition 2b: Excluded Component Cooling Water Valves for Containment Fan Coolers

VFDRs identify valves CC-807B and CC-823B which are normally open valves associated with the B containment fan cooler. The failure of the valves will result in a loss of containment fan cooler water supply. The internal events PRA combined these components with the fan cooler itself based on guidance from NUREG/CR-6928.

A sensitivity study (PSA-WF3-03-01, Att. 1," Mapping of CCS Isolation Valves to Containment Fan Cooler Failures") was performed to determine the impact of not mapping the valves. The valve impact was mapped directly to the containment fan cooler. The sensitivity results indicated that the inclusion of these impacts had no measurable effect on core damage or large early release frequency. The removal of the valves from the mapping has no impact on the fire PRA.

Disposition 2c: Excluded Level Indication on Basis of Low Frequency of Occurrence

Level sensors CC-ILT-7010A and CC-ILT-7010B provide remote indication to CP-8 and maintain normal makeup to the CC surge tank. The PRA credits the secondary flow path that responds on low level in the tank and is typically associated with leakage events in accordance with the PRA modeled failures that deal with divergent flow events.

Although the supply would be present for most postulated fires, components for this path are not powered by onsite emergency power and would be unavailable following a loss of offsite power.

The level switches CC-ILS-7012 (LO) and CC-ILS-70I0 (HI) control CMU-226 operation in AUTO. The automatic controller is mapped to address the need to provide makeup if a flow divergence occurs. The contribution to CCW failure due to divergence has a low frequency contribution.

Since the modeled function is addressed by the automatic makeup and the contribution is low frequency the control panel indication is not required in the PRA.

Disposition 2d: Main Steam Valves MS-119A and MS-119B

Main steam valves MS-119A and MS-119B are drain lines that branch off of the steam lines. The size of the line is 2 inch diameter and the main line is a 40 inch diameter pipe. Based on general PRA guidance branch lines less than one-third the diameter of the main line can be excluded. Therefore, the valves are not included in the fire PRA.

Disposition 2e: HVR-502B Exhaust Fan Blade Pitch Controllers

The internal events system notebook for HVAC indicates that HVR-502B (EDG B exhaust fan blade pitch controller) is not a damper, but a hydro-motor attached to the EDG ventilation fan (E28 3B) and is used to adjust the fan blade pitch to control air flow and room temperature. The internal events PRA combined this component with the fan itself based on guidance from NUREG/CR-6928.

In evaluating the effect of the hydro-motor failing and the pitch going to minimum (minimum flow) the impact would be to make EDG room temperature higher than it would be if the hydro-motors were functioning and controlling temperature.

However, plant experience over several years has demonstrated that there is sufficient margin that even if the fan blades are kept at a minimum pitch that the EDG room temperature was maintained within the design temperature of 120F. This is supported by the inherent margin in the fan design which is greater than 30% capacity.

Therefore, operability of the pitch control is not required for successful fan performance and can be excluded from the PRA model because it does not affect success of the EDG ventilation function. The failure mode is not mapped.

Disposition 2f: CHW-603 and CHW-919 Main Control Room Flow Control Valve

VFDRs identify valves CHW-603 and CHW-919 which are flow control valves associated with the main control room air handling units. The failure of the valves will result in a loss of cooler water supply for the air handling units. The internal events PRA combined these components with the fan cooler itself based on guidance from NUREG/CR-6928.

A sensitivity study was performed to determine the impact of not mapping the valves (PSA-WF3-03-01 Rev 1, Att. 2). The valve impact was mapped directly to the air handling unit. The sensitivity results indicated that the inclusion of these impacts had no measurable effect on core damage or large early release frequency. The removal of the valves from the mapping has no impact on the fire PRA.

Disposition 2g: HVC-ITE-5026A(B) and HVC-ITE-5028A(B) Main Control Room Temperature Instrument

These temperature elements provide temperature indication in the control room. For the fire PRA, habitability is not based on a strict temperature criterion but rather a realistic modeling of the effects of a fire in the main control room. The analysis predicts the time until the area would be considered uninhabitable and evacuation would be required. Since the evacuation is based on physical criteria such as smoke density, room heating, and degree of control panel failure, the instruments are not mapped in the fire PRA.

Disposition 2h: HVC-MAHU-0013A and HVC-MAHU-0013B Air Handling Units

These units are not associated with the main control room. These AHUs are associated with the main control room HVAC room (AHU-26s). AHU-26s are not realistically required due to the load heat load in normal operation (post-LOCA is not applicable to the FPRA) and is estimated to be roughly 5% of capacity. They are excluded based on refined HVAC analysis discussed under Disposition 1.

Disposition 2i: Reactor Pressure and Temperature Instruments

The listed instruments are associated with the ability to monitor subcooling which is most typically associated with cooldown. The end state is hot standby which does not require these instruments for maintaining hot standby; i.e., inability to measure subcooling will not affect mitigation of core damage scenarios at hot standby. Since this is the case, it is not mapped in the fire PRA.

Disposition 2j Steam Generator Pressure Transmitters SG-IPT-1115A and SG-IPT-1125B

The pressure transmitters are associated with the diverse emergency feedwater actuation system (DEFAS) and main feedwater isolation. Main feedwater isolation is not a concern since feedwater is not required or credited. DEFAS would provide an additional EFW start signal and would not provide an adverse response since EFW is the desired fire PRA response for decay heat removal. Since no credit is given for these signals they are not required in the PRA and are not mapped. They do not have any adverse impacts on the fire PRA response model.

Disposition 2k: CVC ILT 227 – Level Transmitter

The level transmitter listed is associated with the volume control tank (VCT). A failure of the transmitter may isolate valves from VCT (CVC-183) and the chemical addition tank and RWSP (CVC-507) to the charging pumps. It would have no effect on the safety injection pumps.

The internal events PRA model success criteria indicates that a loss of charging for a 24 hour period (PRA mission time) combined with normal leakage is insufficient to result in a loss of core cooling based on the accident sequence supporting success criteria documentation . Further, RCS inventory shrinkage is also minimized when the plant state is maintained at hot standby. Therefore, charging is not required for the PRA model and this failure has no impact on the PRA success criteria. Should additional inventory be required due to additional leakage, the PRA credits the safety injection systems to restore level.

Since charging is not required the status of the level transmitter has no impact and it is not modeled based on low probability.

Disposition 2l: Condensate Storage Pool Level Transmitter EFW-ILT-9013B

The instrument provides indication of condensate storage pool (CSP) in the main control room. The time required to deplete the CSP is over nine (9) hours as defined in the PRA success criterion. The long delay time between EFW actuation and low CSP level would provide the operators ample time to deal with any fire-induced failure of CSP level instrumentation and utilize alternative measures. The fire PRA increases the human failure probability by a factor of 10x to address the potential for having to address adverse effects and the level indication is not included in the model.

Disposition 2m: Diesel Generator B Day Tank Level Transmitter EGF-ILT-6903B

The instrument transmitter provides day tank level indication in the control room. Indication is not relied upon to refill the tank. Automatic refill is provided by a separate set of instruments. The level instrument that controls the EGF fuel oil feed pump is EGF-ILS-6907B and this component is modeled in the PRA. No manual actions are credited based on control room instrumentation. The component is not mapped.

Disposition 2n: Makeup System Valves CMU-ISV-0524B, CMU-ISV-0532A/B, CMU-ISV-0532B

A sensitivity study (PRA-W3-05-040 Att. 2, "Documentation of CCW Surge Tank Inventory Depletion Timing for Line Opening"), was performed to assess the impact of flow divergence on CSP depletion time. The assessment indicated that prolonged operation, several hours, would not significantly impact the time available for the operator to accomplish alignment of additional water sources to maintain EFW flow. Since the impact of the postulated divergence of CSP inventory does not have a measureable impact it is screened based on low probability.

Disposition 3: Selected Exclusion based on Postulated Failure Modes

The exclusion involves one or more steps depending on the type of exclusion being considered. The failure mode specified in the VFDR is used to define the component failure modes to be excluded in the analysis.

The interpretation of the failure mode presented in the VFDR is based on the component failure modes addressed in the fire PRA. Another consideration is the type of cable involved. Power and control cables have different potential impacts and, depending on the component, could have no impact at all.

Since the fire-induced failure mode will not result in a credible failure mode for the fire PRA model, it is removed from both the non-compliant and the compliant cases so the net impact on the delta CDF and LERF calculation is zero.

Note that for some components, conflicting failure modes may exist (fails to open and fails to close, for example). The Waterford 3 FPRA includes mutually exclusive logic to exclude both failure modes appearing in a single cut set such that a single impact is defined for each cut set assessment in most all cases.

A few scenarios exist where it is possible to have conflicting failure modes leading to different failure sequences. In that case a validation of the inclusions of all failure modes was performed. Note that the actual failure mode (blocks flow, diverts flow, precludes flow) may make multiple failure modes valid which have the same impact. An example is a failure to close having the same impacts as a transfers open.

Disposition 4: Excluded based on Conservative Instrumentation Modeling

The original fire PRA mapped the instruments for steam generator level (and others) to the operator action that relies on the instrument and not to the instrument itself. As a result the original fire PRA model fails the operator's ability to control SG level if only one of the sensors failed. This is clearly not the case based on discussions with Waterford 3 project staff with operational experience or other similar designed Combustion Engineering plants.

There are five operator actions in the internal events PRA that are related to the level instruments (SG-ILT-1115B and SG-ILT-1125B) of which only one is pertinent to the fire PRA. For that action, the procedural step related to these instruments is met regardless of the loss of a single indicator. Instruments SG-ILT-1113A/B/C/D and SG-ILT-1123A/B/C/D are currently mapped to components and the impact is reflected in the assessment of the operator action probability of success given instrumentation fault.

Disposition 5: Excluded based on Status at Power Operation

SI 401A and B are used only during shutdown cooling operations and are not required in the PRA. Spurious operation of both valves is postulated to initiate an interfacing systems LOCA. However, during power ascension and while at power operation the motive power to these valves is removed. Since power is removed at the breaker there is no motive power to cause the valve to change position so a fire-induced cable fault would not cause the valves to change position. Modeling of cable faults for these valves is not required. This forms the basis of Disposition 5.

The summary of the VFDR categorization as a result of the disposition approach is provided in Table 1 below.

Table 1. VFDR Disposition

Initial VFDRs to Disposition	231	100%
Disposition 1 classes	45	19.5%
Disposition 2 classes	37	16.0%
Disposition 3[1]	8	3.5%
Disposition 4	2	<1%
Disposition 5	2	<1%
Retained for FRE Assessment	137	59.3%

1. Retained for FRE Assessment, reduced modes.

As the table indicates, 62.8% of the VFDRs (Disposition 3 and those not dispositioned) were retained and assessed using the FRE process. Table 1 provides insight into the rationale for excluding VFDRs from the PRA model. Examination shows that almost all exclusions were due to either disposition 1 or disposition 2. For disposition 1 detailed analysis supporting the PRA for room heatup substantially reduced the need for HVAC. The HVAC-associated VFDRs were retained but are not necessary to meet PRA success criteria. Disposition 2 involved similar considerations that involved PRA success criterion. Only 37% of the VFDRs were excluded with over half of those being associated with improved internal events success criteria for HVAC and not on the actual VFDR consideration. The remaining were based on PRA success criteria requirements. This conclusion is drawn that over two thirds were retained and those not addressed explicitly in the PRA were due to the aggregate effects of applying improvements to the PRA modeling.

D). The MCR abandonment scenarios were assessed based on the human performance to assess the implementation of the remote shutdown panel (LCP-43). A conservative criterion was applied that a single operator failure to implement a procedural step was assumed to lead to core damage. This limiting factor dominated the risk contribution but did not result in unacceptable risk consequences. Due to the relatively high contribution derived from the operator action assessment the supporting equipment was not explicitly modeled. Therefore, the model was insensitive to any VFDRs when examining MCR abandonment. Note that the MCR abandonment is being re-evaluated and results will be included in response to RAI PRA S18.

Other MCR scenarios that did not result in abandonment were evaluated and estimates for the risk impact of the variances was determined. This included the main control board and back panel fires that did not cause a significant loss of control and did not require evacuation. In these scenarios the VFDR impacts were excluded in the manner described above and the change in CDF and LERF noted. In some cases the CCDP was calculated to be 1.0 prior to the VFDR being excluded and the exclusion may not have impacted the failures such that the CCDP remained at 1.0. In those cases it was not possible to determine a change in risk associated with the VFDR.

E). The increase associated with retained VFDRs and the net risk reduction due to plant risk reduction actions is provided in Table 2. Note that the removal of combustible materials in RAB 27 and the extension of accumulator mission time were not driven by VFDRs but rather an overall risk reduction strategy and this was based on CDF reduction. In these cases a similar process was performed as for other VFDRs but the risk impact was developed on a total change in CDF. If the total change exceeded the guidance used for the VFDRs a refinement step was performed to determine if any PAU contribution exceeded the change in risk criterion for the VFDRs. If this was found, then the same basis was used to support the plant change.

Table 2 presents the risk impact of the retained, (not brought into compliance) VFDRs to the total CDF and LERF. The first row represents the total risk attributed to the retained VFDRs. These VFDRs were retained because the FRE risk evaluation found their impact was sufficiently small to be acceptable. The next row indicates the total CDF and LERF reduction by implementation of actions to bring VFDRs into compliance. The third and fourth rows are the risk reduction associated with CDF reduction. This includes the removal of combustibles in RAB 27 and the accumulator mission time extension. The risk reduction due to implementing the ERFBS modification was found to be negligible and therefore not necessary to include in this response (RSC-CALKNX-2013-1004).

The total risk decrease from risk reduction modifications is given by the second to last row of Table 2 below. The net change represents the sum of the increases and reductions.

Table 2. Retained VFDR CDF and LERF Risk Contribution

Attribute	Change in CDF (/yr)	Change in LERF (/yr)
Total Risk Increase From Retained VFDRs	2.31E-6 Increase	1.29E-7 Increase
Risk Reduction Actions	3.42E-6 Reduction	8.70E-7 Reduction
Removal of Combustible Materials in RAB 27	2.09E-4 Reduction	Not calculated (Note 1)
Extension of Accumulator Mission Time	7.30E-06 Reduction	Not calculated (Note 1)
Total Risk Decrease from Risk Reduction Modifications	2.20E-4 Reduction	8.70E-7 Reduction

Note 1: CDF reduction was sufficient to justify implementation of change; no calculation of LERF was required.

Based on the results of Table 2 the net decrease far exceeds the retained risk from identified VFDRs and other identified improvements. The total retained risk is considerably lower than the total risk limits identified in Regulatory Guide 1.174 which indicates if the total risk including the sum of the increases due to VFDRs does not exceed the criteria (delta CDF <1E-5 and delta LERF <1E-6), then the risk is deemed acceptable.

PRA RAI S06

By letter dated June 11, 2014, the response to PRA RAI 09 explains that the peer reviews of the Internal Events and Fire PRAs were performed in accordance with the guidelines in NEI 05-04 and NEI 07-12, which reference the clarifications and qualifications of RG 1.200, “An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities.” The response does not explicitly state which revision of RG 1.200 (i.e., Revision 1 or 2) was used in the peer reviews. The licensee's Internal Events PRA peer review appears to indicate that it was performed in 2009 against PRA Standard ASME RA-Sb-2005 as clarified by RG 1.200 Revision 1, dated January 2007. The current guidance for using PRA for risk-informed applications is RG 1.200 Revision 2, dated March 2009 (ADAMS Accession No. ML090410014), which is based on PRA Standard ASME/ANS RA-Sa-2009.

Explain whether the gap assessment was performed for the Internal Events PRA to ASME/ANS RA-Sa-2009 and RG 1.200 Revision 2; if not, determine whether the differences between RG 1.200 Revision 1 and RG 1.200 Revision 2 have any impact on the LAR, and provide a summary of the evaluation.

<u>Waterford 3 Response</u>

The Internal Events peer review (LTR-RAM-II-09-039) was performed using PRA Standard ASME RA-Sb-2005 as clarified by RG 1.200 Revision 1. Both of these documents were the latest available at the time but have since been revised and current PRA quality is judged against Regulatory Guide 1.200 Revision 2 and ASME/ANS RA-Sa-2009.

The Internal Events PRA model at Waterford 3 was updated in 2013 to Revision 5. The Internal Events model documents for this revision (documented in EC 42382) contain individual self-assessments documenting how each relevant High Level Requirement (HLR) and Supporting Requirement are met in the PRA product. These self-assessments were completed using ASME/ANS RA-Sa-2009 clarified by RG 1.200 Revision 2. The Supporting Requirements (SR) for all technical elements, except those associated with internal flooding (which have no impact on the applicability of the PRA model for the NFPA 805 application) are covered in these documents.

SR Category	Source of Self Assessment to ASME/ANS RA-Sa-2009
(AS) – Accident Sequence	PSA-WF3-01-AS, R0 - WF3 PSA At-Power Level 1 Accident Sequence Analysis APPENDIX A: Assessment of WF3 Accident Sequence Capability Category (ASME RA-Sa-2009)
(DA) – Data Analysis	PSA-WF3-01-DA-01, R0 - At-Power Level 1 PRA Plant Specific Failure Data Development Table A.2 ASME Requirements for Data Analysis
(HR) – Human Reliability Analysis	PSA-WF3-01-HR, R0 - WF3 At-Power Level 1 Human Reliability Analysis Notebook Table 1. W3 ASME Capability Category Assessment
(IE) - Initiating Event Analysis	PSA-WF3-01-IE-02, R0 - WF3 PSA At-Power Level 1 Initiating Events Analysis APPENDIX K: Assessment of WF3 Initiating Events Capability
(LE) – Large Early Release Frequency Analysis	PSA-WF3-01-LE, R0 - Large Early Release Frequency (LERF) Model Table B-2: Comparison to ASME PRA Standard Supporting Requirements
(QU) - Quantification	PSA-WF3-01-QU, R0 - WF3 PSA At-Power Level 1 Integration and Quantification Analysis Table G-1. ASME/ANS Requirements for Integration and Quantification
(SC) – Success Criteria	PSA-WF3-01-SC, R0 - WF3 PSA At-Power Level 1 Success Criteria Analysis Appendix C: Assessment of W3 Success Criteria Capability Category
(SY) – Systems Analysis	PSA-WF3-01-SY - PSA Model System Analysis Work Package Appendix 21: Comparison of WF3 System Analysis to ASME PRA Standard

A review of the documents and attachments listed in the above table concluded that with few exceptions all ASME/ANS RA-Sa-2009 Supporting Requirements associated with the internal events PRA model are met at Capability Category II or greater.

As part of the NFPA 805 License Amendment Request application, a self-assessment/gap assessment was completed to document the status of the 2009 peer review findings. Waterford 3 calculation PRA-W3-05-051 "Documentation of PRA Model Quality for the Waterford 3 NFPA 805 LAR" documents this assessment. PRA-W3-05-051 is the site reference for the contents of Attachment U in the LAR Supplement (Waterford 3 Letter W3F1-2013-0048) on Internal Events model quality. The PRA-W3-05-051 analysis was a snapshot of the resolutions to the 2009 peer review, but the assessment was made using the updated ANS/ASME Standard and Regulatory Guide 1.200 Revision 2. The results of that review noted a few supporting requirements (SRs) as not meeting Category II. These SRs are summarized in Attachment U of the LAR with an assessment of the impact for the NFPA 805 application.

Though the last full scope internal events peer review used the previous Standard and Regulatory Guide, the current model has been constructed to meet the updated guidance and no significant gaps exist. Any remaining gaps are documented in the Waterford 3 Model Change Request (MCR) database so that they can be tracked and their potential impacts accounted for in applications where appropriate. All currently open Findings are judged to have a low impact on the PRA model or its ability to support a full range of PRA applications.

For completeness, Waterford 3 will include a Gap Assessment as part of the 120 day RAI Submittal.

PRA RAI S07

90 day response.

PRA RAI S08

By letter dated June 11, 2014, the response to PRA RAI 16 explains that the updated Fire PRA was revised to address sensitive electronics rather than screening them from the analysis. The response to PRA RAI 16 indicates that expanded ZOIs were used to account for sensitive electronics, but the approach was not described in the response. Although the treatment of sensitive electronics may be consistent with recent guidance on modeling sensitive electronics, the licensee's analysis does not cite FAQ 13-0004 (Clarifications on Treatment of Sensitive Electronics, issued December 3, 2013 (ADAMS Accession No. ML13322A085), as one of the FAQs used in the Fire PRA. Explain the updated treatment of sensitive electronics used in the Fire PRA. Include explanation of whether the treatment of sensitive electronics performed for the Fire PRA is consistent with the guidance in FAQ 13-0004, including the caveats about configurations that can invalidate the approach (i.e., sensitive electronics mounted on the surface of cabinets or in the presence of louvers or vents). If the approach cannot be justified using available NRC guidance, then replace the current approach with an acceptable approach as part of the integrated analysis performed in response to PRA RAI S18.

Waterford 3 Response

Sensitive electronics as targets in a potential fire ignition source analysis are treated with a zone of influence (ZOI) investigation. The method for this ZOI analysis uses the Fire Dynamics Tools (FDTs) in NUREG-1805 for fire plume temperature as well as radiant heat flux to calculate temperature and heat flux level at various distances away from various fire sources to arrive at a separation distance away from the fire source at which damage is no longer expected based on the target's (sensitive electronics in this instance) failure criteria. Bounding heat release rates (HRRs) are used as inputs in the FDT analyses and are taken from the presented 98th percentile HRRs in NUREG/CR-6850 for various ignition sources.

The ZOI analysis is carried out on a physical analysis unit (PAU) basis for each counted fixed ignition source as well as for transient ignition sources. The methodology and resultant ZOIs for the various fixed ignition source bins are presented in PRA-W3-05-006F. The methodology and resultant ZOI for the transient ignition source bin is presented in PRA-W3-05-013. Each potential ignition source's ZOI for sensitive electronics is investigated on a case-by-case basis to determine if any sensitive electronics are located within that ZOI for the particular ignition source and if any sensitive electronics are located within that particular ZOI the sensitive electronics are listed as failures for that particular scenario for quantification in the fire PRA results. Similar analyses for oil source fire scenarios are documented in PRA-W3-05-029.

In all of the above analyses, impacts to sensitive electronics use failure criteria taken from NUREG/CR-6850 as 65° C for temperature impacts or 3 kW/m^2 for heat flux impacts. No credit for exposure duration or shielding is taken during the various ZOI analyses for sensitive electronics described above.

One exception to the NUREG/CR-6850 failure criteria for sensitive electronics is taken in the multi-compartment analysis (MCA) fire modeling for PAU RAB7 using CFAST as documented in PRA-W3-05-030. In the RAB7 MCA fire modeling, a temperature failure criterion of 60° C rather than 65° C is used based on previously determined failure criteria for the components housed within the electrical panels (cabinets) of PAU RAB7. The heat flux failure criterion of 3 kW/m^2 is also used in PAU RAB7 for the MCA. The scenario impacts of the MCA fire modeling of PAU RAB7 using CFAST are used to supplement the fixed ignition fire source FDT ZOI analyses of PAU RAB7 for scenario quantification in the fire PRA results.

While FAQ 13-0004 was published after the fire PRA work with regard to sensitive electronics was completed, the work performed is consistent with or bounding of the methodology presented in FAQ 13-0004. Most panels (cabinets) installed at the Waterford 3 plant are ventilated and as such could not make use of the enhanced failure criteria proposed in FAQ 13-0004 but rather would be subject to the lower NUREG/CR-6850 failure criteria which are employed in the current fire PRA analyses for sensitive electronics. The panels (cabinets) within PAU RAB7 could potentially be classified as sealed and robust enclosures and make use of the enhanced failure criteria proposed for use in FAQ 13-0004; however, the panels (cabinets) evaluated in PAU RAB7 using the FDT analyses for fixed source ZOI impacts follow the same treatment as other plant locations and make use of the lower NUREG/CR-6850 failure criteria. Evaluations of the panels (cabinets) within PAU RAB7 for the MCA made use of the previously listed temperature criterion of 60°C rather than 65°C based on previously determined failure criteria for the components housed within the electrical panels (cabinets) of PAU RAB7, and the heat flux failure criterion of 3 kW/m^2 is also used in PAU RAB7 for the MCA. These failure criteria were based on predictions taken on the exterior of the upper surface of the panel (cabinet) as the failure mechanism of interest in the MCA are impacts from a potential hot gas layer, which would be expected to form in the ceiling area above the panels (cabinets) and descend to the top of the panels (cabinets), thus impacting the top surface of the panel (cabinet) first. No credit for shielding is taken during the MCA analysis of PAU RAB7 for sensitive electronics' failure.

As the current treatment of sensitive electronics is consistent with the guidance of NUREG/CR-6850 and consistent with the subsequently published FAQ 13-0004 with the noted more bounding analysis of PAU RAB7 over the enhanced failure criteria proposed in FAQ 13-0004, no additional updates to the current methods, analysis, or results are deemed necessary.

PRA RAI S09

120 day response.

PRA RAI S10

By letter dated June 11, 2014 the response to PRA RAI 28 states, in part, that “the updated analysis no longer uses a floor for joint HEP values,” because a simple multiplier approach is used to determine the HEP of fire event HFEs based on the HEP of Internal Events HFEs. The response indicates that joint HEPs with probabilities lower than 1E-05 are used. NUREG-1921 discusses the need to consider a minimum value for the joint probability of multiple HFEs, and NUREG-1792, “Good Practices for Implementing Human Reliability Analysis (HRA),” issued April 2005 (ADAMS Accession No. ML051160213), Table 2-1 recommends that joint HEP values should not be below 1E-5. Table 4-3 of EPRI 1021081, “Establishing Minimum Acceptable Values for Probabilities of Human Failure Events,” provides a lower limiting value of 1E-6 for sequences with a very low level of dependence.

a. Confirm that each joint HEP value used in the Fire PRA below 1E-5 includes its own justification that demonstrates the inapplicability of the NUREG-1792 lower value guideline.

b. Provide an estimate of the number of these joint HEPs below 1E-5 and at least two different examples of the justification.

Waterford 3 Response

A review of the eight actions is provided below with their inapplicability to NUREG-1792. These represent the eight combinations (JHEPs) utilized in the fire PRA model with probabilities values below 1E-5. From the aggregate cut set file provided in PRA-W3-05-032, the total Fussell-Vesely core damage importance for the JHEPs is 2.42E-4. Based on the reported CDF of 1.55E-5/yr this equates to a CDF contribution from cut sets containing JHEPs of 3.75E-9/yr. Therefore, even a ten-fold increase would have little importance to the current results.

No JHEP utilized in the fire PRA is below 1E-6 using the 10x multiplier suggested when transitioning human actions from internal events to the fire PRA and is consistent with the guidance for screening values given in NUREG-1921. Other JHEPs exist at levels below 1E-5 for the internal events PRA but involve actions or systems not credited in the fire PRA, e.g., auxiliary feedwater.

The EPRI guidance (“Establishing Minimum Acceptable Values for Probabilities of Human Failure Events Practical Guidance for Probabilistic Risk Assessment”, Electric Power Research Institute, EPRI 1021081, October 2010) indicates that lower truncation values can be utilized if justification is provided to determine very low or no dependence.

JHEP Name	JHEP Value	Elements	Comparison to NUREG-1792, Section 5.3.3.6
ZHF-C2-016	1.00E-06	OHFRCPTRIP QHFCSPEMP	The first action in time occurs early when the CCW is lost and the RCPs are tripped. The second involves a much later time when CSP makeup is required for EFW and would utilize a different operator. They address different safety functions and have different cues. This demonstrates that strict adherence to NUREG-1792 is not necessary and application of EPRI 1021081 methodology is reasonable.
ZHF-C2-019	1.00E-06	OHFRCPTRIP HHFISOMINP	The first is associated with RCP trip and the second is an action within the RAB to isolate recirculation lines for HPSI upon receipt of Recirculation Actuation Signal (RAS). These are separated in time, two different operations staff and associated with different functions and cues. Very low or no dependence is anticipated. This demonstrates that strict adherence to NUREG-1792 is not necessary and application of EPRI 1021081 methodology is reasonable.
ZHF-C2-030	1.00E-06	EHFMANTRNP QHFCSPEMP	The first action is associated with transferring loads to the startup transformers following an ABT failure. This would be very close to the time of trip. The second event is associated with CSP refill occurring later in the event and is needed to support continued EFW operation. . They address different safety functions and have different cues. Very low or no dependence is anticipated. This demonstrates that strict adherence to NUREG-1792 is not necessary and application of EPRI 1021081 methodology is reasonable.
ZHF-C3-001	1.00E-06	EHFMANTRNP QHFCSPEMP QHFCSPWCTP	The first action is associated with transferring loads to the startup transformers following an ABT failure. This would be very close to the time of trip. The second and third event are similar actions associated with CSP refill later in the event and is needed to support continued EFW operation which occurs later in the event. The last two would be judged to be completely dependent such that they are a single event since performing same action, same indication, same limiting timing. So can be considered the same as the prior event and the same basis applies. This demonstrates that strict adherence to NUREG-1792 is not necessary and application of EPRI 1021081 methodology is reasonable.

JHEP Name	JHEP Value	Elements	Comparison to NUREG-1792, Section 5.3.3.6
ZHF-C3-003	1.00E-06	OHFRCPTRIP QHFCSPEMP QHFCSPWCTP	The actions associated with the CSP refill to support continued EFW operation are similar and can be considered as a single action as was discussed in the prior event (ZHF-C3-001). Given this assessment then the case is similar to ZHF-C2-016 and the same basis applies. This demonstrates that strict adherence to NUREG-1792 is not necessary and application of EPRI 1021081 methodology is reasonable.
ZHF-C2-014	1.40E-06	EHFMANTRNP QHFCSPWCTP	The first action is associated with transferring loads to the startup transformers following an ABT failure. This would be very close to the time of trip. The second occurs when CSP refill is needed to support continued EFW operation which occurs later in the event. These are separated in time, two different operations staff and associated with different functions and cues. Very low or no dependence is anticipated. This demonstrates that strict adherence to NUREG-1792 is not necessary and application of EPRI 1021081 methodology is reasonable.
ZHF-C2-037	2.40E-06	OHFPZRPRCP HHFISOMINP	The first is associated with RCP trip and the second is an action within the RAB to isolate recirculation lines for HPSI at recirculation. These are separated in time, two different operations staff and associated with different functions and cues. Very low or no dependence is anticipated. This demonstrates that strict adherence to NUREG-1792 is not necessary and application of EPRI 1021081 methodology is reasonable.
ZHF-C2-039	4.00E-06	EHFMANTRNP QHFEFWFLOP	The first action is associated with transferring loads to the startup transformers following an ABT failure. This would be very close to the time of trip. The second occurs when CSP refill is needed to support continued EFW operation which occurs later in the event. These are separated in time, two different operations staff and associated with different functions and cues. Very low or no dependence is anticipated. This demonstrates that strict adherence to NUREG-1792 is not necessary and application of EPRI 1021081 methodology is reasonable.

As demonstrated the identified combinations all exhibit at least two of the following characteristics that reduce the dependence to very low or independent:

- Considerable separation in time.
- At least one action would not occur until a substantial period after the fire would be expected to be suppressed.
- Utilize different staff to perform the function.
- Are based on different cues.
- Support different safety functions.

Therefore the use of a value a decade lower than the NUREG-1792 minimum value is deemed appropriate and consistent with the guidance discussed in EPRI 1021081 that the cut off should not be driven by a strict limit but should be based on reasonable assessment of the dependence in cases where the events exhibit weak or negligible dependence.

PRA RAI S11

By letter dated June 11, 2014 the response to PRA RAI 30 explains that as a result of the revised Fire PRA the "generic" non-suppression factors originally used were removed and non-suppression probability values from NUREG/CR-6850, Supplement 1, were incorporated. The updated approach is not described in the response; however, the NRC staff reviewed the description in the licensee's analysis and notes potential inconsistencies. The licensee's analysis identifies several PAUs (i.e., FPH, RAB 15A, RAB 16A, RAB 20, RAB 40, and RAB 41) for which automatic suppression systems are used as the bases for non-suppression probabilities credited in the Fire PRA. However, these suppression systems appear not to be required in Table C-2 of the LAR supplement for risk reduction. Please explain this apparent inconsistency.

Waterford 3 Response

The fire areas listed (FPH, RAB 15A, RAB 16A, RAB 20, RAB 40, and RAB 41) are all remaining Deterministic and will be maintained under NFPA 805 chapter 4.2.3.2 and not under the Performance Based (i.e. risk informed) approach of NFPA 805 chapter 4.2.4.2. No credit is taken in the Fire PRA for automatic suppression in the FPH fire area. Calculation PRA-W3-05-031 "Development of Fire Non-suppression Factors for WF3 FPRA Scenarios" only notes that this area has installed and functional automatic suppression and that credit would be permissible.

Automatic suppression was credited in the other listed areas (RAB 15A, RAB 16A, RAB 20, RAB 40, and RAB 41) for the base risk numbers calculated for these deterministic areas. All rooms were verified to have installed and functioning automatic suppression systems prior to being credited (PRA-W3-05-031). The credit was applied in an effort to accurately model the as-built, as-operated plant. These suppression features were not credited in fire risk evaluations as these areas have no variances from deterministic requirements (VFDRs). There is no need to credit these suppression features for risk reduction.

These areas all have reasonably low CDF and LERF values and no calculated values for delta CDF/LERF. Moreover, the remaining credited areas (RAB 15A, RAB 16A, RAB 20, RAB 40, and RAB 41) will no longer have licensing actions to require suppression under NFPA 805. Because of other requirements, the suppression systems in these areas will be maintained. In addition, these will be included in the scope of the NFPA 805 Monitoring program.

PRA RAI S12

120 day response.

PRA RAI S13

90 day response.

PRA RAI S14

By letter dated June 11, 2014 the responses to PRA RAI 48 and 43.f identifying modifications that are credited in the PRA do not appear to be fully consistent with the updated Table S-1 in the LAR supplement. Please identify which modifications in the updated Table S-1 are credited in the PRA.

Waterford 3 Response

The following modifications were originally included in LAR Attachment S but were deleted from the LAR Supplement Attachment S: S1-2, S1-3, S1-4, and S1-6. The response to PRA RAI 43.f in submittal W3F1-2014-0025 indicated that S1-7 was no longer required and was withdrawn. S1-7 is not credited in the FPRA analysis.

The following modifications are noted as “In FPRA” in the LAR Supplement Attachment S and are credited for risk reduction: S1-5, S1-8, and S1-14.

S1-5 is an EFRBS (3M fire wrap) in RAB 6. This is credited in the PRA to prevent fire damage to the wrapped cables.

S1-8 is a fire/heat detector upgrade in several fire areas. The current detectors have incorrect (lower temperature) factory set point trip range settings for the normal and accident design temperatures for the applicable fire areas. This modification is not a result of fire risk evaluations, but is assumed in the FPRA model for the appropriate Fire Area detection systems. The detection supports fire suppression and fire brigade response which is credited in the FPRA for several of the areas included in the modification.

S1-14 involves the removal of combustible material from RAB 27. The modification is to remove the combustible material from the area. This configuration change is credited in the fire PRA model. The modification provides a decrease from the threat of the effects of a fire originating from a fire in RAB 27. This change is not associated with a variance from deterministic requirement. The result of the modification is lower overall CDF (little to no impact on delta CDF). Significant combustible material was removed and the fire impacts are significantly reduced.

PRA RAI S15

By letter dated June 11, 2014 the responses to PRA RAI 49 and PRA RAI 45.e explain that quantitative uncertainty analysis was developed for the updated Fire PRA. However, neither these responses nor the licensee’s analysis discuss whether or how state of knowledge correlation (SOKC) is accounted for in the quantitative uncertainty analysis. Mean CDF and LERF values can be affected by SOKC and should be accounted for as part of statistical parametric uncertainty analysis. It is not clear whether SOKC was taken into account in the quantitative uncertainty analysis performed for the updated Fire PRA. PRA Standard Supporting Requirement (SR) QU-A3 (referenced by FQ-A4) and QU-E4 (referenced by FQ-E4) require that the CDF be estimated accounting for the SOKC between event probabilities. The SOKC should include consideration of correlation between probability distributions for Internal Event and Fire PRA parameters (i.e., component type failure mode probabilities, hot short probabilities, and non-suppression probabilities). Summarize the impact of the SOKC correlation on the results reported in Attachment W.

Waterford 3 Response

The state of knowledge correlation (SOKC) addresses the uncertainty that exists when two or more elements in a specific cut set are from the same data source such as two or more basic events associated with the diesel generator failing to start. These are typically identified by the common type code listing found in the CAFTA database file (.RR extension). The SOKC indicates that in these instances the probability of the two events is not represented by the product of the mean values for the like events but rather the product of the mean plus the associated variance. Not including this consideration may lead to underestimation of the cut set contribution and in doing so underestimate the core damage frequency (CDF) or large early release frequency (LERF) contribution. For the Waterford 3 analysis, the results indicate that the calculated estimate for CDF and LERF is not sensitive to the SOKC, as described below.

The Waterford 3 uncertainty assessment was conducted using the UNCERT code which is based on a sampling approach to derive the overall distribution. The Waterford 3 uncertainty applies the component uncertainty characteristics from the internal events model, and the uncertainty parameters associated with fire ignition sources and suppression factors taken from NUREG/CR-6850 and Supplement 1. However, the contribution from SOKC was not explicitly included in the uncertainty analysis for the PRA model.

No variance is specifically provided for the circuit failure probability so it was assumed that the variance was bounded by 10% of the probability of failure or 0.06. This is based on assuming a gamma distribution using α=6, β=10 ("NIST/SEMATECH e-Handbook of Statistical Methods", http://www.itl.nist.gov/div898/handbook/). Using these values the variance is defined as 0.06. The sampling utilizes the associated type code parameters and selects the same value for all events such that the results are completely correlated but this in itself does not address the SOKC contribution.

The estimate of the SOKC impact is developed by a review of the cut sets developed for the uncertainty assessment (PRA-W3-05-032 "Uncertainty Assessment for Waterford 3 Fire PRA, Revision 2"). This included a review of the top 80% of CDF and LERF cut sets to identify any cut set with the conditions requiring a SOKC contribution, had multiple occurrences of the same component failure. From this assessment only twelve CDF cut sets were identified as meeting the condition. These are listed in Table 1.

Table 1. CDF Cut Sets with SOKC Conditions Met

CS	Frequency (/yr)	% of CDF	Cut Set Elements (note pairs highlighted in yellow)					
26	8.02E-08	0.59%	TGB -F43	AA_FAIL3AS	AA_FAIL3BS	EMPOILTRAA	EMPOILTRBA	TGB-F43-NSF
30	7.45E-08	0.55%	TGB -F43	AA_FAIL3AS	AA_FAIL3BS	EDG0DG3ASFE	EDG0DG3BSFE	TGB-F43-NSF
111	1.40E-08	0.10%	TGB -F43	AA_FAIL3AS	AA_FAIL3BS	ECB12A3M4D	ECB312B8MD	TGB-F43-NSF
112	1.40E-08	0.10%	TGB -F43	AA_FAIL3AS	AA_FAIL3BS	ECB12A3M4D	ECB313B8MD	TGB-F43-NSF
113	1.40E-08	0.10%	TGB -F43	AA_FAIL3AS	AA_FAIL3BS	ECB12A3M4D	ECB314B2MD	TGB-F43-NSF
114	1.40E-08	0.10%	TGB -F43	AA_FAIL3AS	AA_FAIL3BS	ECB312A8MD	ECB312B8MD	TGB-F43-NSF
115	1.40E-08	0.10%	TGB -F43	AA_FAIL3AS	AA_FAIL3BS	ECB312A8MD	ECB313B8MD	TGB-F43-NSF
116	1.40E-08	0.10%	TGB -F43	AA_FAIL3AS	AA_FAIL3BS	ECB312A8MD	ECB314B2MD	TGB-F43-NSF
117	1.40E-08	0.10%	TGB -F43	AA_FAIL3AS	AA_FAIL3BS	ECB312B8MD	ECB313A8MD	TGB-F43-NSF
118	1.40E-08	0.10%	TGB -F43	AA_FAIL3AS	AA_FAIL3BS	ECB312B8MD	ECB314A2MD	TGB-F43-NSF
119	1.40E-08	0.10%	TGB -F43	AA_FAIL3AS	AA_FAIL3BS	ECB313A8MD	ECB313B8MD	TGB-F43-NSF
120	1.40E-08	0.10%	TGB -F43	AA_FAIL3AS	AA_FAIL3BS	ECB313A8MD	ECB314B2MD	TGB-F43-NSF
121	1.40E-08	0.10%	TGB -F43	AA_FAIL3AS	AA_FAIL3BS	ECB313B8MD	ECB314A2MD	TGB-F43-NSF
122	1.40E-08	0.10%	TGB -F43	AA_FAIL3AS	AA_FAIL3BS	ECB314A2MD	ECB314B2MD	TGB-F43-NSF

A similar search was performed for the LERF cut set results and is documented in Table 2. Note that all SOKC contributions are associated with the same hot short event pair associated with CARS isolation valves leading to a containment isolation path being open. Paired events are identified in yellow.

Table 2. LERF Cut Sets with SOKC Conditions Met

CS	Frequency (/yr)	% of LERF	Cut Set Elements (note pairs highlighted in yellow)						
1	8.64E-07	18.1%	CRA6T	CROSS PROB1	CROSSP ROB2	EF-CI	-JPURGEOPEN	CRA6T-SF	CRA6T-NSF
4	2.55E-07	5.4	CRA7T	CROSS PROB1	CROSSP ROB2	EF-CI	-JPURGEOPEN	CRA7T-SF	CRA6T-NSF
7	2.03E-07	4.3	7BT05	AALOS PEVTB	CROSSP ROB1	CROSSP ROB2	EF-CI	- JPURGEO PEN	05T01-NSF
8	1.85E-07	3.9	7DT01	CROSS PROB1	CROSSP ROB2	EF-CI	-JPURGEOPEN	05T01-NSF	
9	1.58E-07	3.3	7-F07-MCA-01	CROSS PROB1	CROSSP ROB2	EF-CI	-JPURGEOPEN	7-F01-MCA-01-NSF	
10	1.58E-07	3.3	7-F08-MCA-01	AALOS PEVTB	CROSSP ROB1	CROSSP ROB2	EF-CI	- JPURGEO PEN	7-F01-MCA-01-NSF
11	1.58E-07	3.3	CRA3M	CROSS PROB1	CROSSP ROB2	EF-CI	-JPURGEOPEN	CRA3M-SF	CRA1M-NSF
12	1.08E-07	2.3	CRA4M	CROSS PROB1	CROSSP ROB2	EF-CI	-JPURGEOPEN	CRA4M-SF	CRA1M-NSF
13	1.05E-07	2.2	7-F09-MCA-01	AALOS PEVTB	CROSSP ROB1	CROSSP ROB2	EF-CI	- JPURGEO PEN	7-F01-MCA-01-NSF
14	1.04E-07	2.2	CRA3S	CROSS PROB1	CROSSP ROB2	EF-CI	-JPURGEOPEN	CRA3S-SF	CRA1M-NSF
15	7.85E-08	1.6	7-F06-MCA-01	CROSS PROB1	CROSSP ROB2	EF-CI	-JPURGEOPEN	7-F01-MCA-01-NSF	
16	7.54E-08	1.6	CRA1M	CROSS PROB1	CROSSP ROB2	EF-CI	-JPURGEOPEN	CRA1M-SF	CRA1M-NSF
17	6.19E-08	1.3	CRA2M	CROSS PROB1	CROSSP ROB2	EF-CI	-JPURGEOPEN	CRA2M-SF	CRA1M-NSF
18	5.24E-08	1.1	7-F10-MCA-01	CROSS PROB1	CROSSP ROB2	EF-CI	-JPURGEOPEN	7-F01-MCA-01-NSF	
19	5.08E-08	1.1	7DT03	CROSS PROB1	CROSSP ROB2	EF-CI	-JPURGEOPEN	05T01-NSF	
21	4.74E-08	1.0	CRA1S	CROSS PROB1	CROSSP ROB2	EF-CI	-JPURGEOPEN	CRA1S-SF	CRA1M-NSF
22	4.31E-08	0.9	CRA8T	CROSS PROB1	CROSSP ROB2	EF-CI	-JPURGEOPEN	CRA8T-SF	CRA6T-NSF
23	3.95E-08	0.8	7DT02	CROSS PROB1	CROSSP ROB2	EF-CI	-JPURGEOPEN	05T01-NSF	

Summing the LERF contributions of these cut sets (Table 2) yields a frequency value of 2.75E-6/yr.

To determine the SOKC contributions for CDF the identified cut sets were adjusted to include the variance in the probability term for the component pairs. The impact of the state of knowledge correlation is to increase the contribution of the correlated basic events. The increase is equal to the variance. The equation is represented by:

P(SOKC) = P(A) x P(B) + Var

This equation is used along with the cut sets to define the increase. The first cut set (#26) is used as an example.

The frequency of the cut sets is 8.02E-8/yr. The component probability is 5.69E-3 with a variance of 4.62E-7. The first step is to remove the existing contribution P(A) x P(B) [5.69E-3 x 5.69E-3 = 3.2376E-5]. The “partial” cut set value is 2.48E-3. Multiplying this value by the variance (4.62E-7) yields the SOKC increase

The results were then summed to determine the additional CDF value. Table 3 summarizes the process for each identified CDF cut set in Table 1.

Table 3. Evaluation of SOKC Contribution to CDF

CS	CS Frequency (/yr)	SOKC Component Probability	Type Code	Variance Value	Partial CS Frequency (/yr)	SOKC Contribution (/yr)
26	8.02E-08	5.69E-03	MP_A	4.62E-07	2.48E-03	1.14E-09
30	7.45E-08	5.50E-03	DG_FE	8.07E-08	2.46E-03	1.99E-10
111	1.40E-08	2.38E-03	CB_D	5.95E-06	2.47E-03	1.47E-08
114	1.40E-08	2.38E-03	CB_D	5.95E-06	2.47E-03	1.47E-08
115	1.40E-08	2.38E-03	CB_D	5.95E-06	2.47E-03	1.47E-08
116	1.40E-08	2.38E-03	CB_D	5.95E-06	2.47E-03	1.47E-08
117	1.40E-08	2.38E-03	CB_D	5.95E-06	2.47E-03	1.47E-08
118	1.40E-08	2.38E-03	CB_D	5.95E-06	2.47E-03	1.47E-08
119	1.40E-08	2.38E-03	CB_D	5.95E-06	2.47E-03	1.47E-08
120	1.40E-08	2.38E-03	CB_D	5.95E-06	2.47E-03	1.47E-08
121	1.40E-08	2.38E-03	CB_D	5.95E-06	2.47E-03	1.47E-08
122	1.40E-08	2.38E-03	CB_D	5.95E-06	2.47E-03	1.47E-08
					TOTAL	1.48E-07

The SOKC contribution is obtained by taking the initial cut set and dividing out the identified pair probability to arrive at a partial CS frequency. This is then multiplied by the variance to arrive at the SOKC contribution. Using the process an additional frequency of 1.48E-7/yr is calculated.

A similar process can be used for the LERF. However, since in all cases the same pair is involved, it can be simplified to a single calculation involving the sum of the contribution as presented in Table 4.

Table 4. Evaluation of SOKC Contribution to LERF

LERF Frequency (/yr)	SOKC Component Probability	Basic Event(s)	Variance Value	Partial CS Frequency (/yr)	SOKC Contribution (/yr)
2.75E-06	0.6	Crossprob	0.06	7.63E-06	4.58E-07

Table 5 summarizes the assessment of the SOKC contributions for CDF and LERF.

Table 5. Comparison of Baseline to Adjusted CDF and LERF

Figure of Merit	Baseline	Adjusted for SOKC	Difference
CDF (/yr)	1.32E-5/yr	1.33E-5/yr	1.1%
LERF (/yr)	4.72E-6/yr	5.18E-6yr	9.7%

The results indicate that the calculated estimate for CDF and LERF is not sensitive to the SOKC. Based on the review, the basis for the low contribution is that, for the most part, the results are dominated by cut sets that do not represent combinations of component random failures. Fire-induced failures of components are completely dependent within a scenario with no severity factor included such that there is not a SOKC adjustment required.

For the LERF scenarios the result is controlled by cut set contributions that are devoid of any component failures not completely dependent on the presence of the fire. The 9.7% difference is associated with cut sets including circuit failure probabilities related to the CARS system. The impact is strongly associated with the assumption on variance associated with the hot short probability.

The approved analysis method for calculating the impacts of hot shorts is NUREG/CR-7150, Vol. 2/EPRI 3002001989, “Joint Assessment of Cable Damage and Quantification of Effects from Fire (JACQUE-FIRE)”, which provides updated estimates for the probability of hot short and also includes estimates for uncertainty. Considering information from this source indicates a variance level of 0.01 is more likely which would significantly reduce the impact of SOKC and would further support the conclusion that the SOKC considerations do not impact the results and conclusions derived from the fire PRA.

Waterford 3 will add to implementation item S2-22 to employ NUREG/CR 7150, Vol 2 methods.

PRA RAI S16

90 day response.

PRA RAI S17

90 day response.

PRA RAI S18

120 day response.

PRA RAI S19

120 day response.

Enclosure 2 to

W3F1-2015-0015

Revised Attachment A
NFPA 805 Chapter 3 Requirement 3.11.3
Waterford 3 NFPA 805 License Amendment Request

Attachment A - NEI 04-02 Table B-1 Transition of Fundamental Fire Protection Program & Design Elements

NFPA 805 Ch. 3 ref.	Requirements/Guidance	Compliance Statement	Compliance Basis	Reference Documents
3.11.3 Fire Barrier Penetrations. (2)	3.11.3* (2) NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems	Complies via Previous Approval	HVAC duct penetrations through fire area boundaries separating the corridor/vestibule portion of Fire Area RAB 3A (Heating and Ventilation Room, Elevator Machine Room) from Fire Zones RAB 8B (Switchgear Room B) and RAB 8C (Switchgear Room A/B) (Fire Area RAB 8) and Fire Area RAB 25 (Equipment Access Area) from Fire Area RAB 32 (Pipe Penetrations: Auxiliary Component Cooling Water Pumps) do not have rated fire dampers (Reference LAR, Attachment K, Deviations 16 and 42). The lack of fire dampers in HVAC ductwork separating Fire Area RAB 3A from Fire Zones RAB 8B and RAB 8C and Fire Area RAB 25 from RAB 32 were previously approved by the NRC in letter dated January 17, 1995 (ILN95-0017) and in NUREG 0787, Supplement No. 8, dated December, 1984 respectively.	ILN 95-0017 Rev. 000 [All] - Safety Evaluation by the Office of Nuclear Reactor Reg. - Re-Evaluation of Previous Exemption from the Requirements of Appendix R to 10 CFR Part 50, Sect. III.G.2 - Entergy Operations, Inc, Waterford Steam Electric Station, Unit 3 - Docket No. 50-382 NUREG-0787, Supplement No. 8 Rev. 12/84 [Section 9.5.1.3(2)] - Safety Evaluation Report - related to the operation of Waterford Steam Electric Station Unit No. 3 - Docket No. 50-382 WF3-FP-13-00005 Rev. 000 [Attachment 7.1, Deviations 16 & 42] - WF3 Review of Licensing Actions for NFPA 805 Transition
		Complies with use of EEEE's	Waterford 3 compliance with the requirements in NFPA 90A, 1974 Edition, for air-conditioning and ventilation systems credited in Chapter 4 to meet the Nuclear Safety Performance Criteria, is documented in Engineering Report No. WF3-FP-10- 00017 and engineering equivalency evaluations documented in WF3-FP-11-00003 and in WF3-FP-13-00006. No other NFPA standards were determined to be applicable.	WF3-FP-10-00017 Rev. 001 [All] - WF3 Code Compliance Report for NFPA 90A, 1974 Edition Standard for Installation of Air Conditioning and Ventilating Systems WF3-FP-11-00003 Rev. 000 [Section 6.2.] - WF3 Review and Evaluation of Fire Protection Engineering Evaluations for NFPA 805 WF3-FP-13-00006 Rev. 000 [Attachments 8.1, 8.3 & 8.4] - Evaluation of Fire Area Boundaries