GE-Hitachi Nuclear Energy Americas LLC

James C. Kinsey
Project Manager, ESBWR Licensing

PO Box 780 M/C A-55
Wilmington, NC 28402-0780
USA

T 910 675 5057
F 910 362 5057
jim.kinsey@ge.com

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Subject: Response to Portion of NRC Request for Additional Information Letter No. 91 Related to ESBWR Design Certification Application ESBWR Probabilistic Risk Assessment RAI Numbers 19.1-117 through 19.1-133, 19.1-140, 19.1-142, 19.1-144, 19.1-148, 19.2-69 through 19.2-74 and 19.2-76 through 79.

The purpose of this letter is to submit the GE-Hitachi Nuclear Energy Americas LLC (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by NRC letter dated January 31, 2007. GEH responses to RAI Numbers 19.1-117 through 19.1-133, 19.1-140, 19.1-142,19.1-144, 19.1-148, 19.2-69 through 19.2-74 and 19.2-76 through 19.2-79 are addressed in the Enclosure.

Should you have any questions about the information provided here, please contact me at 910-675-5057 or jim.kinsey@ge.com.

Sincerely,

Kathy Sedney for

James C. Kinsey
Project Manager, ESBWR Licensing

D068
NRO

Reference:

1. MFN 07-104, Letter from U.S. Nuclear Regulatory Commission to David H. Hinds, *Request for Additional Information Letter No. 91 Related to ESBWR Design Certification Application.* January 31, 2007.

Enclosure:

1. Response to Portion of NRC Request for Additional Information Letter No. 91 Related to ESBWR Design Certification Application ESBWR Probabilistic Risk Assessment RAI Numbers 19.1-117 through 19.1-133, 19.1-140, 19.1-142,19.1-144, 19.1-148,19.2-69 through 19.2-74 and 19.2-76 through 79.

cc:	AE Cubbage	USNRC (with enclosure)
	GB Stramback	GEH/San Jose (with enclosure)
	RE Brown	GEH/Wilmington (with enclosure)
	EDRF Section	0000-0072-3040 RAI 19.1-117 through 19.1-121 and 19.1-123
		0000-0072-7391 RAI 19.1-122
		0000-0072-2017 RAI 19.1-124 through 19.1-130
		0000-0072-1016 RAI 19.1-140
		0000-0072-3040 RAI 19.1-142,19.1-144, 19.1-148
		0000-0072-2646 RAI 19.2-69
		0000-0072-2649 RAI 19.2-70
		0000-0072-5377 RAI 19.2-71
		0000-0072-2651 RAI 19.2-72
		0000-0072-2654 RAI 19.2-73
		0000-0072-2655 RAI 19.2-74
		0000-0072-5378 RAI 19.2-76
		0000-0072-5379 RAI 19.2-77
		0000-0072-2049 RAI 19.2-78 and 19.2-79

Enclosure 1 of MFN 07-423

Response to Portion of NRC Request for Additional Information Letter No. 91 Related to ESBWR Design Certification Application ESBWR Probabilistic Risk Assessment RAI Numbers 19.1-117 through 19.1-133, 19.1-140, 19.1-142, 19.1-144, 19.1-148, 19.2-69 through 19.2-74 and 19.2-76 through 79

NRC RAI 19.1-117

Shutdown event trees in Mode 6 cover conditions with the reactor vessel head removed and with the head on (but with one or more of the head closure bolts less than fully tensioned). In the Mode 6 event trees, the assumption is made that the head is removed and, therefore, no RCS pressure control is needed for RCS injection and gravity driven cooling system (GDCS). Please explain in the PRA why modeling of Mode 6 with the head on is not needed.

GEH Response

A new mode has been added to the shutdown PRA analysis called Mode 5 Open. It is not a Technical Specification defined mode, but is assessed differently in NEDO-33201, Rev 2 because it is Mode 5 conditions with an open containment. This mode is assumed to also account for the short time in Mode 6 when the reactor vessel head is still on.

According to the Technical Specification mode definitions, Mode 6 begins when one or more reactor vessel head closure bolts is less than fully tensioned. Mode 5 Open sequences consider pressure relief in the model. Mode 6 sequences do not since the RPV head is removed for the majority of the mode. Due to the Technical Specification definition, there is a small period of time that is technically Mode 6, but where the vessel head may still provide a pressure seal. Mode 6 with the vessel head still on is assumed bounded by the Mode 5 Open event trees and analysis (NEDO 33201 Chapter 16, Section 16.2.1.3).

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

NEDO-33201, Chapter 16, Rev 2 will be revised as noted above.

NRC RAI 19.1-118

For the shutdown PRA, the staff is unable to determinate what mitigating systems are automated and what mitigating systems require manual action. Since shutdown risk is driven by human error for current plants, the staff needs to review the shutdown fault trees to understand required human actions during shutdown modes. Please provide the shutdown fault trees.

GEH Response

Specific shutdown fault trees are not needed. For the shutdown analysis, the level one fault trees were used. Differences in logic between Level 1 conditions and shutdown were accounted for with flag files when quantifying the shutdown model.

For example:

The Isolation Condenser System has four loops. In the Level 1 model, the ICS success criterion is the proper function of any 2 out of 4 loops. Tech Specs allow two of the four loops to be out of service for Mode 5. For the sequences in Mode 5 that credit ICS, 2 out of 2 loops are required to meet the success criteria. A flag file sets two of the ICS loops to TRUE (failed) during shutdown quantification. So the same fault tree is used, but only two ICS loops are available, and any failure that fails a single loop causes loss of ICS.

Only three systems credited in the shutdown PRA are automated. ICS, ADS, and GDCS are the only three systems that do not require a manual action to initiate. ADS actually has three credited modes in shutdown. Two are automated and one is manual. The automated modes include the opening of any one of 18 SRVs for overpressure protection, and Automatic Depressurization if the RPV coolant reaches L1. The manual action includes operators manually opening 2 SRVs. FAPCS, FPS, RWCU (re-start following LOPP) and CRD pumps all require operator action to initiate during shutdown. CRD pumps would automatically start on reactor level 2 during normal operation. This auto start is assumed to be unavailable for shutdowns modes and is flagged out of the logic for quantification.

All fault tree logic can be viewed in the associated system sections of NEDO-33201 Chapter 4. For shutdown specific treatment of systems, refer to NEDO-33201 Chapter 16, Section 16.4.1 and 16.5.

DCD Impact

No DCD changes will be made in response to this RAI.

NEDO-33201 Rev 2 has been revised as noted above.

NRC RAI 19.1-119

The shutdown PRA does not evaluate loss of reactor vessel inventory through human error. Since automatic isolation of reactor water cleanup/shutdown cooling system (RWCU/SDC) on low reactor vessel level is not required by Technical Specifications in Modes 5 and 6, please explain how loss of inventory through an empty feedwater line has been evaluated during shutdown.

GEH Response

Loss of inventory through a feedwater line would require the passive failure of three or more valves. Feedwater line A has a motor operated valve (MOV) (F100A), and three check valves in series (F101A, F102A, F103A) prior to its connection to the RPV. The RWCU/SDC line connects to feedwater line A between F102A and F103A. If RWCU train A is running during shutdown, three valves need to fail to remain closed (two check valves and an MOV). If Train B were running, loss of inventory through line A would require four passive valve failures. Scenarios involving more than one passive failure have not been included in the model.

Additionally, RWCU/SDC will isolate on low level in Mode 5. The DCD is currently being changed to specify this. The NRC staff is already aware of this per a more recent RAI:

> *NRC RAI 19.1-142*
> *Provide P&IDs for the reactor water cleanup/shutdown cooling system.* ***The staff was recently informed that the Technical Specifications will be revised to require RWCU/SDC Isolation during Modes 5 and 6 on low reactor vessel level.*** *However, it appears that there are numerous piping connections upstream of the RWCU/SDC containment isolation valves and the opening of valves in such piping could drain the vessel since the drain path would not be isolated by the proposed RWCU/SDC isolation. The staff notes that loss of reactor vessel inventory caused by human error is not currently addressed in the shutdown PRA. Please provide P&IDs for the RWCU/SDC to enable the staff to evaluate shutdown risk estimates for human error induced vessel diversion paths.*

The current ESBWR RWCU/SDC design significantly reduces the likelihood of a human error that induces RPV leak/diversion. The only lines inside containment with the possibility of a leak are only 20mm (NEDO 33201 Chapter 16/RAI 19.1-86 Response) and are too small to be considered initiating events. Any leak or diversion outside containment would be automatically isolated on RPV low level.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

NEDO-33201 Rev 2 Chapter 16 will be revised as noted above.

NRC RAI 19.1-120

Please explain whether the Passive Containment Cooling System (PCCS) is functional with an open containment. Containment integrity is not required in Modes 5 and 6 and, if PCCS is not functional, credit for PCCS should be removed from the shutdown event trees for Modes 5 and 6.

GEH Response

PCCS has been removed from the shutdown model. The system is no longer credited in any shutdown event trees.

DCD Impact

No DCD changes will be made in response to this RAI.

NEDO-33201 Rev 2 Chapter 16 will be revised as noted above.

NRC RAI 19.1-121

Please explain the factor of ten reduction in shutdown LOCA frequencies compared to full power LOCA frequencies. The staff notes that shutdown LOCA frequencies were not reduced by a factor of 10 in the AP1000 PRA, and the staff is not aware of any operating data that support the factor of 10 reduction.

Please evaluate the RWCU/SDC heat exchanger bypass flow line to determine whether the line is susceptible to thermal fatigue.

GEH Response

A sensitivity is included in the results section of NEDO-33201 Chapter 16 to present results both with and without the LOCA frequency reduction factor (NEDO-33201 Chapter 16, Section 16.6.2.1).

The methodology for reducing shutdown LOCA frequencies was borrowed from:

"Evaluation of Potential Severe Accidents During Low Power and Shutdown Operations at Grand Gulf, Unit 1, NUREG/CR-6143, Vol. 2, Part 1 A, June 1994"

Additional basis for reducing pipe failure frequencies during shutdown conditions are offered in NEDO-33201 Rev 2 Chapter 16, Section 16.3.1.2.1. Those include:

- Primary pipe failure mechanisms are related to pressure and temperature. These mechanisms are significantly reduced during shutdown conditions
- In IS-LOCA analysis, without RPS pressure, IS-LOCA is not credible. During shutdown, pressure is significantly less than during power operation.

Shutdown LOCA frequencies at European plants are calculated using reduction factors to account for smaller pressure and temperature. (Source: NEA/CSNI/R(2005)11/VOL121-Sep-2005 "IMPROVING LOW POWER AND SHUTDOWN PSA METHODS AND DATA TO PERMIT BETTER RISK COMPARISON AND TRADE-OFF DECISION-MAKING"/ NUCLEAR ENERGY AGENCY (NEA) - COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

The RWCU heat exchanger bypass line is not relevant to any LOCA analysis whether or not it is susceptible to thermal fatigue. Any leak will be automatically isolated and not considered a LOCA event. RWCU containment penetrations have two sets of isolation valves. The valve sets are diverse, redundant automatic isolation valves that are required to be operable in Modes 5 & 6. The isolation signal will isolate a bypass line break (or any other RWCU break outside containment) on either RPV low level, or RWCU flow mismatch. Only RWCU LOCA events inside containment are included in the shutdown PRA. Thermal fatigue evaluations will be performed in accordance with ASME Code requirements.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

NEDO-33201 Rev 2 Chapter 16 will be revised as noted above.

NRC RAI 19.1-122

Please provide a sensitivity study in the shutdown PRA that credits only the systems required to be operable according to Technical Specifications. This request is related to SECY 97-168, in which the staff concluded that the current level of shutdown safety was achieved by voluntary measures that are not required by current regulations, and that these measures could be withdrawn by licensees without NRC approval.

GEH Response

Three of the credited systems in the shutdown PRA model are required to be available by the Technical Specifications. Isolation Condenser System (ICS) and Gravity Driven Cooling System (GDCS) are the only systems explicitly covered by Tech Specs in shutdown modes. ADS function is also required by Tech Specs to support GDCS venting.

A sensitivity study has been performed with the following changes to the baseline shutdown model. All FAPCS, FPS, CRD and RWCU/SDC nodes were flagged to TRUE (failed). Recovery actions and system independent operator actions (closure of drywell hatch) are unchanged from the baseline shutdown case.

The results of the sensitivity are:

CDF with only systems required by Tech Specs:	less than 5E-7
Baseline shutdown CDF:	less than 1E-8

There is a fairly significant increase in the CDF, but the results are still relatively low. There are two primary reasons that the difference in the two cases is not all that great. One reason is that the top cutsets in the baseline case (making up 98% of the CDF) are unaffected by the sensitivity. These cases are below TAF LOCA events and the only mitigation is closing the lower drywell hatches. These sequences are not the top cutsets in the sensitivity case, but many are in the top 15 cutsets, and all are still in the top 50. The second reason is that all the systems removed from the model are entirely dependant on human action. The only three automated systems (ICS, GDCS, ADS) are still credited. The systems removed from the model had much higher failure values due to reliance on operators.

The numbers presented result from the requested sensitivity. However, regulations besides the Tech Specs will be in place for other systems. The fire protection system (FPS) will be required to have at least one or more pumps available because of the plant Fire Protection Program or other regulatory requirements. FAPCS availability is not covered in Tech Specs, but the system will be in continuous operation for spent fuel pool cooling. These two systems are not credited in the sensitivity, are not covered in Tech Specs for shutdown modes, but they are expected to be available.

Crediting only systems required operable by Tech Specs for shutdown, both the CDF and LERF results are well within the safety goals. Based on the values obtained in this analysis (no credit for systems that are certain to be available through other commitments), no additional regulatory oversight appears necessary with respect to the level of shutdown safety.

DCD/NEDO-033201 Impact

No DCD changes will be made in response to this RAI.

NEDO-33201 Rev 2 Chapter 11 contains the details of the sensitivity case above.

NRC RAI 19.1-123

Please explain in the shutdown PRA whether the ESBWR design has considered the Shutdown Management Guidelines in NUMARC 91-06, including:

(1) how the automatic isolation function of the DHR system (on low RPV level) should be maintained during shutdown cooling periods (NUMARC 91-06 guideline 4.2.3); and,

(2) how containment closure can be achieved in sufficient time to prevent potential fission product release (NUMARC Guidelines 4.5).

GEH Response

ESBWR designers are aware of the NUMARC 91-06 Guidelines. They are also aware that if constructed and operated, the plant will implement voluntary measures (along with the required measures) to protect key safety functions during shutdown.

With respect to the two specific questions above, both functions will be controlled by regulated (not voluntary) measures:

(1) DHR isolation during shutdown is currently being revised in the DCD. It will be required by Technical Specifications to be available in shutdown modes. RWCU/SDC isolation operability will be maintained, and the system will isolate on low RPV level and flow mismatch. See GE's responses to: NRC RAI 16.2-45, and NRC RAI 19.1-119 for details of the RWCU isolation function during shutdown, and the Tech Spec treatment of the issue.

(2) Due to the unique design of the ESBWR, containment closure during refueling activities is not possible in a timely manner. The top of the upper drywell is actually removed during refueling. This is similar to the ABWR in that regard.

Some containment closure activities to prevent fission product release are controlled however. The results of the shutdown PRA indicate that the majority of the risk at shutdown (98% of the shutdown CDF) is associated with LOCA events in the lower drywell. Timely closing of the lower drywell equipment and personnel hatches prevents core damage in most scenarios with the containment head removed (due to the size of the vessel and the amount of water above the core). For the two types of postulated lower drywell LOCA events, times of 90 minutes and 6 hours are available to close the hatch and prevent CDF. Closure of the lower drywell hatches is controlled via the Availability Controls Manual (ACM), which is part of DCD Tier 2. The section below pertains to the lower drywell hatch during shutdown, and is taken from the ACM.

ACM 3.6 CONTAINMENT SYSTEMS

AC 3.6.2 Lower Drywell Hatches

ACLCO 3.6.2 The lower drywell personnel air lock and lower drywell equipment hatch shall be AVAILABLE for closure.

APPLICABILITY: MODES 5 and 6, during operations with a potential for draining the reactor vessel (OPDRVs).

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. Required Drywell equipment hatch not AVAILABLE for closure.	A.1	Initiate action to suspend OPDRVs.	Immediately
B. Required Action and associated Completion Time not met.	B.1	Enter ACLCO 3.0.3.	Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
ACSR 3.6.2.1	Verify lower drywell hatch administrative closure plan is in place.	12 hours
ACSR 3.6.2.2	Verify lower drywell equipment hatch can be secured closed.	30 days
ACSR 3.6.2.3	Verify lower drywell personnel airlock can be secured closed.	30 days

An equipment hatch for removal of equipment during maintenance and an air lock for entry of personnel are provided in the lower drywell. These access openings are sealed under normal plant operation but may be opened when the plant is shut down. Closure of both hatches is required for the shutdown Loss-of-Coolant Accident (LOCA) below top of active fuel (TAF) initiators during MODES 5 and 6. These LOCAs involve breaks in the RWCU/SDC drain lines and instrument lines and CRD housing/maintenance activities. Once the event has been detected, personnel must correctly diagnose the situation, make the decision to close the hatches, and manually close the equipment hatch and the personnel air lock. Administrative controls assure trained personnel will be continuously located in the area of the doors and appropriate administrative controls are in place to communicate awareness of potential breaches and effect decisions to secure the hatches.

The lower drywell hatch closure function is a nonsafety-related function that satisfies the significance criteria for Regulatory Treatment of Non-Safety Systems, and therefore requires regulatory oversight. The short-term availability controls for this function, which are specified as Completion Times, are acceptable to ensure that the availability of this function is consistent with the functional unavailability in the ESBWR PRA. The surveillance requirements also provide an adequate level of support to ensure that component performance is consistent with the functional reliability in the ESBWR PRA.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33201 Rev 2 changes will be made in response to this RAI.

NRC RAI 19.1-124

Please provide the definition of a shutdown initiating event in the shutdown PRA sections that address internal events, shutdown fire, and shutdown flooding.

GEH Response

A shutdown initiating event is defined as any event that provokes a disturbance in the desired state of the plant and that requires some kind of action to prevent damage to the core. The postulated shutdown initiating events related to internal events, fire and flooding will challenge:

- Decay Heat Removal (includes Loss of RWCU/SDC, Loss of Preferred Power. And Loss of all Service Water), or
- Reactor Coolant System Inventory Control (includes several postulated LOCAs during shutdown).

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

NEDO-33201, Rev 2 has been revised with the shutdown initiating events as described above.

NRC RAI 19.1-125

Explain why a postulated fire causes an SRV to open. Please explain in the shutdown fire assessment why the assumption that a postulated fire causes an SRV to open is conservative given that the SRVs must open for low pressure injection via feedwater or control rod drive hydraulic systems.

GEH Response

In Revision 2 of the shutdown fire PRA analysis, fire-induced IORV is not a shutdown fire initiating event. Line breaks, or a stuck-open relief valve, that occur above RPV level L3 are not initiating events because RWCU/SDC and a natural circulation flow path are available.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

NEDO-33201, Rev 2 will be revised as described above.

NRC RAI 19.1-126

Please explain in the shutdown fire PRA the definition and capability of a fire watch when fire barriers are not intact. The staff needs additional information to assess the fire propagation failure rate of .0074 between barriers when fire watches are used instead of fire barriers.

GEH Response

During shutdown conditions, a fire barrier may not be intact due to maintenance activities. However, an added fire watch would not only increase the success probability of fire detection and suppression, but also help restore the fire barrier in time to prevent fire propagation. Shutdown fire risks related to the fire barriers are evaluated and managed in accordance with the outage risk management program of 10CFR50.65(a)(4).

F-V and RAW values for the modeled fire barriers are used to evaluate the importance of the fire barriers. Sensitivity cases are used to evaluate the fire risk increases from the increased failure probabilities of the fire barriers. The sensitivity study results are documented in NEDO-33201 Section 11, which will be issued September 28, 2007.

DCD/NEDO-33210 Impact

No DCD changes will be made in response to this RAI.

NEDO-33201, Rev 2 will be revised as described above.

NRC RAI 19.1-127

Please clarify whether the referenced fire watch in the shutdown fire PRA is a roving watch or a continuous watch with capability to communicate to the control room. If the fire watch is a roving fire watch, please specify in the shutdown fire PRA the frequency the fire watch will monitor fire areas with breached barriers.

GEH Response

See the response to RAI 19.1-126.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

No changes to the subject LTR will be made in response to this RAI.

NRC RAI 19.1-128

Please clarify the units in NEDO-33201, Revision 1, Table 12-9, Table 12-12, and Table 12-16. For example, when frequencies are referenced as per year, explain whether it is a shutdown year (where the plant is in the shutdown mode for a calendar year) or a calendar year (where the plant is expected to be full power most of the time).

GEH Response

In Tables 12-9 and 12-10, the units of fire frequencies are in a shutdown year. In Tables 12-12 and 12-16, the units are in a calendar year. This was done to add the shutdown risk directly to the at-power risk values.

DCD Impact

No DCD changes will be made in response to this RAI.

LTR NEDO-33201, Rev 2 will be revised as described above for more clarity.

NRC RAI 19.1-129

The shutdown technical specifications do not require operability of automatic systems, with the exception of GDCS. Please explain how the shutdown control room fire risk analysis considers that the operability of automatic systems is not required, with the exception of GDCS on low reactor vessel level.

GEH Response

The ESBWR main control room (MCR) is designed differently from the traditional main control room. The ESBWR MCR controls are connected to the back panel rooms via fiber-optic cables, which are unaffected by the MCR fire. The loss (including melting) of the cables or Visual Display Units (VDUs) will not cause inadvertent actuations or affect the automatic actions associated with safety and nonsafety equipment. The fires in the back panel rooms are evaluated separately with consideration of the impact on the operability of automatic systems.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

NEDO-33201, Rev 2 will be revised as described above.

NRC RAI 19.1-130

Please perform a sensitivity study which credits only safety-related equipment for accident mitigation in the shutdown fire PRA and provide the top 100 cutsets. This information is needed to support the RTNSS process. Requests for Additional Information (RAIs) NEDO-33201, Revision 1, "ESBWR Probabilistic Risk Assessment".

GEH Response

A focused fire PRA analysis including the top 100 cutsets will be performed after all the relevant model elements are finalized (e.g., fire PRA models, shutdown PRA models, etc.), and will be submitted in Revision 2 NEDO-33201 Section 11 on September 28, 2007.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

NEDO-33201, Rev 2 will be revised as described above.

NRC RAI 19.1-131

In the shutdown flooding PRA (general assumption 29), it is assumed that the flooding duration through open hatches is sufficiently short such that Containment flood scenarios involving an open Containment are non-significant. Containment integrity is not required during Modes 5 and 6. Therefore, containment can be open the entire duration of Modes 5 and 6. Current BWR licensees de-inert and open containment early to stage equipment maintenance. Please justify in the shutdown flooding PRA how the duration of time that the equipment hatches and personnel hatches are opened is sufficiently short such that containment flood scenarios involving an open containment are non-significant. Requests for Additional Information (RAIs) NEDO-33201, Revision 1, "ESBWR Probabilistic Risk Assessment

GEH Response

NEDO-33201 Section 13 will be revised to delete general assumption 29. Containment flood scenarios will address an open containment.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

NEDO-33201 Rev. 2 will be revised as described above.

NRC RAI 19.1-132

In the shutdown flooding PRA, it is stated that a line break in the RWCU/SDC system outside Containment, combined with failure of automatic isolation of the break, will result in flooding the lower floor of the Reactor Building and the lower floor of the Fuel Building via the door separating the two areas. Please revise the shutdown flooding PRA to reflect that automatic isolation of RWCU/SDCS is not required in Modes 5 and 6, or explain why the shutdown flooding PRA should not be changed.

GEH Response

Per DCD Tier 2, Rev. 3, Technical Specification 3.3.6.3 and 3.3.6.4 the RWCU/SDCS isolation function is operable in Modes 5 and 6. Because it is now required in Modes 5 and 6, the shutdown flooding PRA should not be changed.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33201 Rev. 2 changes will be made in response to this RAI.

NRC RAI 19.1-133

Please evaluate the risk impact of a shutdown LOCA during Modes 5 and 6 and the propagation of that flood via an opened equipment hatch to other flood areas (such as the reactor building). In the flooding PRA, it is stated that, during shutdown conditions, LOCA frequencies are much lower than at-power conditions,and as such, shutdown LOCAs are non-significant risk contributors and are not analyzed further in this analysis. However, the staff has found that LOCAs at shutdown with an open containment dominate the total ESBWR release frequency risk.

GEH Response

The risk impact of a shutdown LOCA and the propagation of that flood via an open equipment hatch to other flood areas during Modes 5 and 6 will be included in NEDO-33201 Section 13.

Major piping in containment will be included as flooding sources in the shutdown flooding analysis. The effect on PRA equipment of having the drywell equipment hatch open and the drywell personnel hatch open during shutdown flooding conditions on equipment which is modeled in the PRA will be included in the model.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

NEDO-33201 Rev. 2 will be revised as described above.

NRC RAI 19.1-140

Please address the potential risk associated with flooding that could result from the use of temporary penetrations associated with refueling (e.g., refueling cavity seal failure).

GEH Response

The potential risk associated with flooding that could result from the use of temporary penetrations such as a refueling cavity seal failure is conservatively assumed to be the loss of all systems. However, as stated in NEDO-33201 Section 16, even with the loss of all systems, adequate water remains in the vessel to prevent core damage for 24 hours. (The refueling cavity seal is permanently installed on the ESBWR.)

Failure of the refueling cavity seal with no containment hatches open would flood containment. Failure of the refueling cavity seal with the equipment hatch in the drywell open could cause flooding of the fuel building which houses FAPCS equipment. Failure of the refueling cavity seal with the drywell personnel hatch open could result in flooding of the RWCU/SDC Train B equipment. With both drywell hatches open, failure of RWCU/SDC Train B and FAPCS may occur. However, RWCU/SDC Train A would not be affected by flooding caused by failure of the refueling cavity seal.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33201 Rev. 2 changes will be made in response to this RAI.

NRC RAI 19.1-142

The staff was recently informed that the Technical Specifications will be revised to require RWCU/SDC Isolation during Modes 5 and 6 on low reactor vessel level. However, it appears that there are numerous piping connections upstream of the RWCU/SDC containment isolation valves and the opening of valves in such piping could drain the vessel since the drain path would not be isolated by the proposed RWCU/SDC isolation. The staff notes that loss of reactor vessel inventory caused by human error is not currently addressed in the shutdown PRA. Please provide P&IDs for the RWCU/SDC to enable the staff to evaluate shutdown risk estimates for human error induced vessel diversion paths.

GE Response

Though not a P&ID, DCD Chapter 5, Figure 5.1-4 contains a schematic of the RWCU/SDC system.

An evaluation of system piping drawings showed two potential draindown paths due to misalignment. Both lines have 20mm diameters and are assumed to be too small to be considered an initiating event. (NEDO 33201, Chapter 16, Section 16.3.1.2.2)

Two potential draindown paths exist upstream of the containment isolation valves per train (a total of four). The first one on each train is a 20mm line to the Primary Sample System. This line has a 20 mm drain connection upstream of the containment isolation valves and a line that goes to the Primary Sample System. The drain connection has two normally closed manual isolation valves and is a capped connection. The line to the Primary Sample System has two normally closed/fail closed isolation valves with valve position indication available. The second path on each train is a 20mm vent line with two normally closed manual isolation valves and a pipe cap installed.

DCD/NEDO-033201 Impact

No DCD changes will be made in response to this RAI.

NEDO-33201 Rev 2 Chapter 16, Section 16.3.1.2.2 will be revised as noted above.

NRC RAI 19.1-144

Please provide calculations to demonstrate that short term and long term core cooling can be provided by isolation condenser system operation following an extended loss of the RWCU/SDC function from a cold shutdown condition. This information will assist the staff to address thermal-hydraulic uncertainty in the ESBWR passive design regarding shutdown success criteria.

GEH Response

The Technical Specifications for the ICS system require at least two of the four loops are operational during Mode 5 (Cold Shutdown). Additionally, the ICS instrumentation & actuation logic are required to be operable in Mode 5 (DCD LCO 3.3.5.3 and 3.3.5.4). ICS is only credited for Mode 5 during shutdown. It will not function during Mode 6 with the reactor vessel head removed.

Loss of RWCU/SDC during shutdown would cause RPV pressure and temperature to both increase to near or above Mode 1 conditions. It is assumed that following loss of RWCU/SDC, the ICS would respond just at it would to a transient during power operations. The primary difference is that only two ICS loops are available and both are needed to meet the success criteria.

Two ICS heat exchangers can remove 1.5% of decay heat. This level of decay heat occurs between 2000 and 4000 seconds following shutdown. Mode 5 (Cold Shutdown) will not occur until well after this time. Two functioning Isolation Condensers can meet the long term and short-term core cooling needs during Cold Shutdown.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

NEDO-33201 Rev 2 Chapter 16 will be revised as described above.

NRC RAI 19.1-148

Evaluate in shutdown PRA the consequences of a drained suppression pool during Modes 5 and 6. The shutdown PRA credits SRV actuation with relief to the suppression pool during Modes 5 and 6 following an extended loss of RWCU/SDC and, additionally,it appears that suppression pool level is necessary for GDCS operation at shutdown for long term cooling. However, suppression pool level is not required by Technical Specifications in Modes 5 and 6. Please evaluate in the PRA: (1) consequences of relieving steam to an empty suppression pool (e.g. suppression pool over-pressurization) and (2) consequences of an empty suppression pool on GDCS operation.

GEH Response

The probability of having an empty suppression pool combined with another initiating event (loss of RWCU/SDC) is assumed to be negligible.

The volume of the suppression pool (at Low Water Level) is 11.5 million gallons (DCD/Tier 2, Table 6.2-3).

Additionally, draining the suppression pool is not a normal event during BWR outages. A planned significant reduction in SP level would be treated as a special configuration.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33201 Rev 2 changes will be made in response to this RAI.

NRC RAI 19.2-69

Include probability of hydrogen combustion when containment is not inerted. Reference: PRA Revision 1, Section 8.1 The probability of hydrogen combustion during the periods when the containment is not inerted (typically 24 hours) prior to and following shutdown needs to be included within the risk profile.

GEH Response

The increased risk of hydrogen combustion during de-inerted operation is included as described in NEDO-33201 Section 8.1.4. De-inerted operation within the scope of the at-power Level 2 PRA occurs only during Mode 4, which will last for 8 hours, and low power startup. However, to conservatively bound the risk of de-inerted operation, it is assumed at 24 hours per reactor year. All core damage during this time is assumed to result in combustible gas deflagration and containment bypass.

DCD Impact

No DCD changes will be made in response to this RAI.

Section 8 of NEDO-33201, rev 2 will be revised as described in the above response.

NRC RAI 19.2-70

In Section 8.1.3, GE justifies not addressing the potential for containment failure due to combustible gas deflagration on the basis that the containment would remain inerted for significantly greater than 24 hours following an accident. However, the potential for combustion related containment failures in accidents occurring during the period of de-inerted operation prior to and following shutdown was not addressed. Provide an assessment of the contribution to large release frequency from events occurring during the period of de-inerted operation.

GEH Response

The increased risk of hydrogen combustion during de-inerted operation is included as described in NEDO-33201 Section 8.1.4. De-inerted operation within the scope of the at-power Level 2 PRA occurs only during Mode 4, which will last for 8 hours, and low power startup. However, to conservatively bound the risk of de-inerted operation, it is assumed at 24 hours per reactor year. All core damage during this time is assumed to result in combustible gas deflagration and containment bypass.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

Section 8 of NEDO-33201, Rev 2 will be revised as described in the above response.

NRC RAI 19.2-71

Confirm whether the MAAP parameter file reflects the current design. Identify any design changes that have not yet been incorporated and discuss the impact of these changes on the PRA, and the schedule for incorporating these changes into the ESBWR analysis. Please explain how the chimney region above the core is modeled in MAAP, or, if no model enhancements were made, how it is treated in the MAAP parameter file.

GEH Response

The significant changes to the MAAP parameter file include the following:

1) ICS condensate holdup vessels added – described in DCD/TIER 2 Revision 3 Section 5.4.6.2.2 (7^{th} bullet in section).
2) Removal of Level 1.5 – DCD/TIER 2 Revision 3 Table 15.2-1 (table does not mention deletion of Level 1.5 but lists all of the vessel level trips).
3) Adjustment of Level 1 – DCD/TIER 2 Revision 3 Table 15.2-1.
4) LDW spillover pipes changed to spillover holes – described in DCD/TIER 2 Revision 3 Section 6.2.1.1.2.
5) Non-ADS SRVs discharge to Upper DW – described in DCD/TIER 2 Revision 3 Section 5.2.2.2.2 and Figure 5.2-1.
6) Fire Protection System capacity 1.1E6 gallons – DCD/TIER 2 Revision 3 Table 9.5-2.
7) GDCS tanks walls changed from concrete to metal – DCD/TIER 2 Revision 3 Figure 3G.1-59.
8) Total mass of UO2 in active core region increased – parameter file update.
9) Area of flowpath for recirculated water leaving steam separator (AUDSS) increased – parameter file update.
10) Changes to mass of top guide (decreased) and mass of shroud head (increased) – parameter file update move chimney from top guide to shroud head.
11) Mass of Inner/Outer PCCS/ICS Pools increased – parameter file update.
12) Containment nodalization was updated including separation of DW Head area from upper DW – parameter file update.
13) Containment junction revised to reflect nodalization update – parameter file update.
14) Update Containment heat sinks – parameter file update.

The MAAP parameter file reflects the current design with the exception of the Containment Hydrogen Removal system. The addition of this system was approved. However, detailed design is not complete. This system is not important to the ESBWR PRA since core damage when de-inerted is conservatively assumed to result in a containment bypass sequence. This system will be evaluated when detailed design is complete as part of the PRA Update Process.

The chimney region above the core is modeled as part of the shroud head including the mass of the chimney.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

No changes to NEDO-33201 will be made in response to this RAI.

NRC RAI 19.2-72

(A) With the exception of release category "FR", there is essentially no information provided on accident progression and chronology, containment response, and source term release magnitude and timing for any of the release categories and representative sequences. Provide such additional details for each of the representative sequences listed in Table 9-1.

(B) Of particular interest is Sequence T_nDP_nIN_VB in Section 8.3.2.3, for cases where vacuum breaker failure has occurred (release category OPVB;Section 9.8). Please provide detailed accident chronology and pressure and temperature plots for this sequence in Section 8.3.2.3.

(C) It would be very useful if the representative sequences included one where neither the deluge system nor the BiMAC were functional. Moreover,sequences where CCI occurs should be included (one with wet CCI and one with dry CCI). Please include such sequences.

(D) For all sequences presented, please include plots of the upper drywell temperature and lower drywell temperature in addition to the plots already presented.

GEH Response

A) NEDO-33201 Table 9-1, Revision 2 provides information for all release categories regarding accident frequency, time to initial release, and release fractions of noble gases and CsI at both 24 and 72 hours. Appendix 9A, Rev 2 contains plots for all calculated containment response. Variables are provided for each of the representative cases listed in Table 9-1.

B) Details of the accident chronology and containment response for the representative "OPVB" cases (T_nDP_nIN_VB_R1 and T_nIN_VB_R1) are shown in Appendix 9A. Section 8 only explicitly shows details for accident scenarios in which control of the containment boundary is maintained (TSL and FR).

C) In Section 9, Table 9-1, the "CCID" cases address a failure of the GDCS Deluge system to inject to the lower drywell. The "CCIW" cases feature successful Deluge operation but unsuccessful core cooling due to postulated BiMAC failures as a result of phenomenon uncertainty. The Deluge system must function for the BiMAC to be exposed to failure; the CCID cases provide scenarios in which neither the Deluge nor the BiMAC are functional. Both dry and wet CCI cases are included.

D) Upper and lower drywell plots are among the plots for each case now included in Appendix 9A of NEDO-33201.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

NEDO-33201, Rev 2 Table 9-1 and Appendix 9A will be revised as described above.

NRC RAI 19.2-73

The probability of successful containment vent operation is assumed to be independent of initiating event and support systems. Provide justification for the probability value and for the use of the same value for all CSETs. Include a description of the vent valves, their associated support systems, and the operator actions required to open and to reclose the valves, and the locations and environmental conditions where these actions would be taken.

GEH Response

In NEDO 33201, Rev 2, the containment venting valves are modeled with a fault tree as in the Level 1 analysis. Support systems such as Q-DCIS, instrument air, and DC power are fully modeled so that initiator impact is explicitly captured in the results. The vent valves are air-operated with remote manual actuation from the main control room. Re-closure of the valves is not considered because venting guidance is currently unavailable; instead the release is assumed to continue uninhibited once initial venting is commenced. As severe accident mitigation guidelines become available, the containment venting model will be updated accordingly. See NEDO-33201 Sections 8.2.1.3.10 and 8A.2.8 for further information.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

NEDO-33201 Section 8 will be modified to model containment venting as described above.

NRC RAI 19.2-74

Given the structure of the CPETs and CSETs in Appendix A.8 of the PRA,Containment Isolation/Bypass is not questioned in the CPETs, and is only questioned in the CSETs (i.e., for those events which transfer from the CPET to the CSET.) The consequences for all of the release categories assigned in the CPET (e.g., CCI-W, CCI-D, EVE, and DCH) are less severe than for the Bypass release category considered in the CSET. As such, the decision to question Containment Isolation/Bypass only for those events that transfer to the CSET (rather than addressing this question for all events) results in an under-estimate of the frequency and risk of bypass events. Provide an assessment of the impact on LRF and risk results if Containment Isolation/Bypass was questioned earlier in the event tree.

GEH Response

The effect of relocating the CIS node to the beginning of the Containment Event Tree (CET) is not expected to have a significant effect because of the low probability of the phenomenological events that precede CIS in the current CETs. A sensitivity study quantifying the effect on release frequency when the CIS node is considered first will be documented in NEDO-33201 Section 11, Revision 2.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

Section 11 of NEDO-33201 will be revised as described in the above response.

NRC RAI 19.2-76

Address operator actions to flood containment in accordance with the Severe Accident Guidelines. Reference: PRA Revision 1, Section A.8.2.6 Confirm whether operator actions to flood containment in accordance with Step RC/F-2 of the Severe Accident Guidelines (including maximizing injection into the RPV and primary containment from sources external to the primary containment when water level cannot be maintained above top of active fuel) have been explicitly considered in GE's probability estimates for a deeply flooded LDW at the time of reactor vessel breach. If not, provide an assessment of: (1) the impact of the containment flooding guidelines on the Level 2 and 3 PRA results, and (2) the need for further revisions to the ESBWR risk model to address operator actions to flood containment.

GEH Response

The severe accident guidelines for the ESBWR have not been developed at this time. Due to the design of the ESBWR containment with the BiMAC and deluge system, it is assumed that the containment will not be flooded until after reactor vessel breach. This assumption will be included in the development of the severe accident guidelines for the ESBWR. The severe accident guidelines for the ESBWR will be developed in the future and in accordance with the Human Factors Engineering process.

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

No changes to the NEDO-33201 will be made in response to this RAI.

NRC RAI 19.2-77

In Section 9.5, it is stated that damage to the lower drywell liner would not result in a direct release path to the environment, even though the failure area would be much larger than that associated with normal leakage. To justify this statement,please describe the pathway from the lower drywell to the environment, and document radionuclide deposition along this pathway.

GEH Response

The Direct Containment Heating release category described in PRA Section 9.5 has been analyzed conservatively assuming that the release is directly to the environment from the drywell. No credit has been taken for deposition on the structural concrete backing the drywell liner or in the reactor building.

DCD Impact

No DCD changes will be made in response to this RAI.

No changes to NEDO-33201 will be made in response to this RAI.

NRC RAI 19.2-78

Provide an explanation of how a COL applicant would demonstrate that their site specific meteorological and population data is bounded by the meteorological and population data assumed in the ESBWR design certification analyses. Provide either a reference for the specific data or the actual data files.

GEH Response

The three risk goals, especially the three radiological consequence design goals are one order of magnitude lower numerically than the NRC risk goals. As stated in Section 10 of NEDO-33201, these goals are considered as the criteria for meteorological reference data and for the population data bounding requirement.

A sensitivity study is presented in Section 10.5 of NEDO-33201, Revision 2 to illustrate that the ESBWR radiological design goals are adequate bounding comparing with various results of the sensitivity study of two representative meteorological conditions.

In the sensitivity study, two meteorological conditions are studied. The summary of the two meteorological conditions are listed below.

The first meteorological condition is also used for the ESBWR Level 3 base case study. This meteorological condition is comparable with that of ALWR URD meteorological reference data, which represents 80% of all sites.

The second meteorological condition represents a narrower distribution condition. The narrower distribution can represent slightly conservative radiological consequence in certain wind sectors and with certain stability classes. The importance of the sensitivity study is to reveal the radiological consequences compared to the three risk goals.

The detail of the three risk goals and the more conservative design goals are listed in Section 10.4 of NEDO-33201.

The population data used in the ESBWR Level 3 PRA analysis adopted a uniform population approach with a more bounding 0-10 mile population density than that provided in the ALWR URD.

A 790 person/miles^2 population density used in the ESBWR Level 3 PRA analysis is conservative. The sensitivity study has shown that the three risk goals are also bounding with population density variations.

In conclusion, the sensitivity study shows that variation of meteorological and population data do not result in radiological consequence risk results that are several orders of magnitude lower than the three risk goals. As such, it is our belief that the generic ESBWR Level 3 analysis is bounding and is suitable for revealing risk insights.

Meteorological Data Summary

<u>Case 1 – Base Case</u>

**METEOROLOGICAL DATA FILE CONTAINS 459 HOURS OF OBSERVED RAIN DATA.
ACCUMULATED RAIN MEASUREMENTS TOTALED 26.77 INCHES FOR THE YEAR.
CONSTANT LID HEIGHTS (M) FOR 4 SEASONS = 1500 1500 1500 1500
NON-ZERO WINDSPEEDS LESS THAN 0.5 M/S ARE SET TO 0.5 M/S**

*** * * * METEOROLOGICAL BIN SUMMARY * * * ***

BIN PRIORITIES

RI XX - RAIN INTENSITY I WITHIN THE INTERVAL ENDING AT XX

INTERVAL ENDPOINTS ARE IN KILOMETERS FROM THE ACCIDENT SITE, THE 5 INTERVAL ENDPOINTS ARE 3 8 16 32 64

RAIN INTENSITIES ARE IN MILLIMETERS OF RAIN PER HOUR, THE 3 INTENSITY BREAKPOINTS ARE 2.0 4.0 6.0

S V - INITIAL WEATHER CONDITIONS WITH STABILITY CLASS S AND WIND SPEED INTERVAL V

STABILITY CLASSES ARE B = A/B, D = C/D, E = E, AND F = F

WIND SPEED INTERVALS ARE IN METERS PER SECOND, 1 (0-1), 2 (1-2), 3 (2-3), 4 (3-5), 5 (5-7), 6 (GT 7)

	WIND DIRECTION																
METBIN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	TOTAL	PER CENT
1 B 3	0.045	0.067	0.083	0.101	0.141	0.078	0.071	0.085	0.109	0.044	0.035	0.035	0.036	0.026	0.014	0.029	1174	13.4018
2 B 4	0.010	0.060	0.179	0.218	0.233	0.093	0.080	0.060	0.041	0.011	0.002	0.002	0.002	0.002	0.008	0.000	614	7.0091
3 D 1	0.042	0.018	0.024	0.055	0.036	0.036	0.048	0.061	0.109	0.097	0.109	0.067	0.097	0.097	0.079	0.024	165	1.8836
4 D 2	0.047	0.065	0.070	0.061	0.075	0.096	0.072	0.061	0.136	0.086	0.070	0.047	0.047	0.019	0.021	0.028	428	4.8858
5 D 3	0.022	0.070	0.169	0.191	0.126	0.126	0.130	0.044	0.054	0.019	0.009	0.006	0.017	0.007	0.007	0.004	540	6.1644
6 D 4	0.004	0.049	0.216	0.385	0.208	0.054	0.054	0.013	0.011	0.005	0.001	0.000	0.000	0.000	0.000	0.000	759	8.6644
7 D 5	0.000	0.006	0.154	0.586	0.173	0.062	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	162	1.8493
8 D 6	0.000	0.000	0.125	0.750	0.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	8	0.0913
9 E 1	0.065	0.025	0.022	0.009	0.022	0.012	0.015	0.015	0.034	0.043	0.056	0.118	0.183	0.170	0.121	0.090	323	3.6872
10 E 2	0.121	0.090	0.065	0.050	0.050	0.040	0.031	0.027	0.052	0.069	0.121	0.115	0.087	0.025	0.029	0.027	520	5.9361
11 E 3	0.060	0.183	0.226	0.162	0.094	0.094	0.072	0.021	0.013	0.034	0.009	0.017	0.004	0.009	0.000	0.004	235	2.6826
12 E 4	0.057	0.133	0.304	0.361	0.108	0.019	0.006	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.006	0.000	158	1.8037
13 F 1	0.026	0.018	0.007	0.002	0.001	0.001	0.003	0.005	0.014	0.012	0.019	0.034	0.114	0.259	0.365	0.120	1153	13.1621
14 F 2	0.147	0.056	0.018	0.009	0.002	0.002	0.005	0.004	0.009	0.030	0.044	0.086	0.086	0.088	0.209	0.207	570	6.5068
15 F 3	0.418	0.187	0.154	0.066	0.011	0.000	0.022	0.000	0.011	0.066	0.022	0.000	0.000	0.000	0.000	0.044	91	1.0388
16 F 4	0.048	0.048	0.214	0.548	0.143	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	42	0.4795
17 R1 3	0.092	0.084	0.124	0.081	0.051	0.054	0.032	0.043	0.019	0.032	0.049	0.151	0.057	0.059	0.035	0.035	370	4.2237
18 R1 8	0.103	0.087	0.087	0.048	0.048	0.048	0.032	0.008	0.032	0.040	0.079	0.087	0.079	0.095	0.071	0.056	126	1.4384
19 R1 16	0.089	0.128	0.111	0.083	0.050	0.022	0.056	0.022	0.028	0.033	0.044	0.078	0.056	0.061	0.072	0.067	180	2.0548
20 R1 32	0.088	0.075	0.111	0.068	0.062	0.036	0.039	0.020	0.039	0.020	0.065	0.111	0.059	0.055	0.088	0.065	307	3.5046
21 R1 64	0.078	0.135	0.154	0.116	0.036	0.019	0.026	0.017	0.028	0.045	0.095	0.071	0.055	0.047	0.038	0.040	422	4.8174
22 R2 3	0.080	0.067	0.120	0.053	0.053	0.013	0.027	0.000	0.027	0.107	0.080	0.173	0.067	0.040	0.067	0.027	75	0.8562
23 R2 8	0.071	0.214	0.000	0.071	0.071	0.000	0.000	0.000	0.000	0.214	0.143	0.071	0.000	0.143	0.000	0.000	14	0.1598

24	R2	16	0.063	0.250	0.094	0.031	0.063	0.000	0.000	0.031	0.031	0.125	0.094	0.031	0.125	0.031	0.031	0.000	32	0.3653
25	R2	32	0.020	0.176	0.098	0.078	0.098	0.000	0.039	0.039	0.000	0.020	0.078	0.118	0.098	0.039	0.059	0.039	51	0.5822
26	R2	64	0.048	0.083	0.155	0.107	0.012	0.000	0.000	0.000	0.000	0.012	0.083	0.071	0.155	0.071	0.071	0.131	84	0.9589
27	R3	3	0.000	0.048	0.238	0.190	0.095	0.000	0.000	0.000	0.000	0.048	0.048	0.190	0.095	0.000	0.048	0.000	21	0.2397
28	R3	8	0.000	0.000	0.000	0.000	0.400	0.200	0.000	0.000	0.200	0.000	0.000	0.000	0.200	0.000	0.000	0.000	5	0.0571
29	R3	16	0.154	0.077	0.308	0.154	0.077	0.000	0.000	0.077	0.077	0.000	0.000	0.000	0.077	0.000	0.000	0.000	13	0.1484
30	R3	32	0.200	0.100	0.100	0.100	0.100	0.000	0.000	0.000	0.000	0.000	0.050	0.100	0.200	0.000	0.050	0.000	20	0.2283
31	R3	64	0.209	0.116	0.163	0.116	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.070	0.070	0.047	0.093	0.093	43	0.4909
32	R4	3	0.000	0.000	0.105	0.053	0.158	0.158	0.053	0.000	0.000	0.105	0.053	0.158	0.053	0.000	0.053	0.053	19	0.2169
33	R4	8	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.333	0.000	0.000	0.000	3	0.0342
34	R4	16	0.000	0.200	0.400	0.400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5	0.0571
35	R4	32	0.000	0.200	0.200	0.200	0.000	0.100	0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.000	10	0.1142
36	R4	64	0.111	0.222	0.056	0.111	0.056	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.167	0.167	0.111	18	0.2055
37	ALL		0.059	0.069	0.107	0.126	0.088	0.048	0.044	0.032	0.043	0.033	0.040	0.051	0.057	0.066	0.085	0.051	8760	

WIND DIRECTION

METBIN			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	TOTAL	PER CENT
1	B	3	53	79	98	118	165	92	83	100	128	52	41	41	42	31	17	34	1174	13.4018
2	B	4	6	37	110	134	143	57	49	37	25	7	1	1	1	1	5	0	614	7.0091
3	D	1	7	3	4	9	6	6	8	10	18	16	18	11	16	16	13	4	165	1.8836
4	D	2	20	28	30	26	32	41	31	26	58	37	30	20	20	8	9	12	428	4.8858
5	D	3	12	38	91	103	68	68	70	24	29	10	5	3	9	4	4	2	540	6.1644
6	D	4	3	37	164	292	158	41	41	10	8	4	1	0	0	0	0	0	759	8.6644
7	D	5	0	1	25	95	28	10	3	0	0	0	0	0	0	0	0	0	162	1.8493
8	D	6	0	0	1	6	1	0	0	0	0	0	0	0	0	0	0	0	8	0.0913
9	E	1	21	8	7	3	7	4	5	5	11	14	18	38	59	55	39	29	323	3.6872
10	E	2	63	47	34	26	26	21	16	14	27	36	63	60	45	13	15	14	520	5.9361
11	E	3	14	43	53	38	22	22	17	5	3	8	2	4	1	2	0	1	235	2.6826
12	E	4	9	21	48	57	17	3	1	0	0	1	0	0	0	0	1	0	158	1.8037
13	F	1	30	21	8	2	1	1	3	6	16	14	22	39	132	299	421	138	1153	13.1621
14	F	2	84	32	10	5	1	1	3	2	5	17	25	49	49	50	119	118	570	6.5068
15	F	3	38	17	14	6	1	0	2	0	1	6	2	0	0	0	0	4	91	1.0388
16	F	4	2	2	9	23	6	0	0	0	0	0	0	0	0	0	0	0	42	0.4795
17	R1	3	34	31	46	30	19	20	12	16	7	12	18	56	21	22	13	13	370	4.2237
18	R1	8	13	11	11	6	6	6	4	1	4	5	10	11	10	12	9	7	126	1.4384
19	R1	16	16	23	20	15	9	4	10	4	5	6	8	14	10	11	13	12	180	2.0548
20	R1	32	27	23	34	21	19	11	12	6	12	6	20	34	18	17	27	20	307	3.5046
21	R1	64	33	57	65	49	15	8	11	7	12	19	40	30	23	20	16	17	422	4.8174
22	R2	3	6	5	9	4	4	1	2	0	2	8	6	13	5	3	5	2	75	0.8562
23	R2	8	1	3	0	1	1	0	0	0	0	3	2	1	0	2	0	0	14	0.1598

24 R2 16	2	8	3	1	2	0	0	1	1	4	3	1	4	1	1	0	32	0.3653
25 R2 32	1	9	5	4	5	0	2	2	0	1	4	6	5	2	3	2	51	0.5822
26 R2 64	4	7	13	9	1	0	0	0	0	1	7	6	13	6	6	11	84	0.9589
27 R3 3	0	1	5	4	2	0	0	0	0	1	1	4	2	0	1	0	21	0.2397
28 R3 8	0	0	0	0	2	1	0	0	1	0	0	0	1	0	0	0	5	0.0571
29 R3 16	2	1	4	2	1	0	0	1	1	0	0	0	1	0	0	0	13	0.1484
30 R3 32	4	2	2	2	2	0	0	0	0	0	1	2	4	0	1	0	20	0.2283
31 R3 64	9	5	7	5	1	0	0	0	0	0	0	3	3	2	4	4	43	0.4909
32 R4 3	0	0	2	1	3	3	1	0	0	2	1	3	1	0	1	1	19	0.2169
33 R4 8	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	3	0.0342
34 R4 16	0	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	5	0.0571
35 R4 32	0	2	2	2	0	1	1	0	0	0	0	0	0	0	2	0	10	0.1142
36 R4 64	2	4	1	2	1	0	0	0	0	0	0	0	0	3	3	2	18	0.2055

* * * * SUMMARIES * * * *

R	155	193	231	160	93	55	55	38	45	69	121	184	122	101	105	91	1818	20.7534
B	59	116	208	252	308	149	132	137	153	59	42	42	43	32	22	34	1788	20.4110
D	42	107	315	531	293	166	153	70	113	67	54	34	45	28	26	18	2062	23.5388
E	107	119	142	124	72	50	39	24	41	59	83	102	105	70	55	44	1236	14.1096
F	154	72	41	36	9	2	8	8	22	37	49	88	181	349	540	260	1856	21.1872
1	58	34	20	15	21	18	16	24	57	44	59	90	208	375	474	174	1687	19.2580
2	183	135	103	97	140	91	78	76	134	119	141	160	135	80	150	158	1980	22.6027
3	101	147	226	224	168	147	144	92	105	47	26	15	30	23	13	24	1532	17.4886
4	20	93	309	467	291	88	88	47	33	11	2	1	1	1	6	0	1458	16.6438
5	0	5	47	132	60	23	6	0	0	1	0	0	0	0	0	0	274	3.1279
6	0	0	1	8	2	0	0	0	0	0	0	0	0	0	0	0	11	0.1256

Case 2 – Sensitivity Case

METEOROLOGICAL DATA FILE CONTAINS 409 HOURS OF OBSERVED RAIN DATA.

ACCUMULATED RAIN MEASUREMENTS TOTALED 52.85 INCHES FOR THE YEAR.

CONSTANT LID HEIGHTS (M) FOR 4 SEASONS = 1065 1534 1593 898

NON-ZERO WINDSPEEDS LESS THAN 0.5 M/S ARE SET TO 0.5 M/S

*** * * * METEOROLOGICAL BIN SUMMARY * * * ***

BIN PRIORITIES

RI XX - RAIN INTENSITY I WITHIN THE INTERVAL ENDING AT XX

INTERVAL ENDPOINTS ARE IN KILOMETERS FROM THE ACCIDENT SITE, THE 5 INTERVAL ENDPOINTS ARE 3 8 16 32 64

RAIN INTENSITIES ARE IN MILLIMETERS OF RAIN PER HOUR, THE 3 INTENSITY BREAKPOINTS ARE 2.0 4.0 6.0

S V - INITIAL WEATHER CONDITIONS WITH STABILITY CLASS S AND WIND SPEED INTERVAL V

STABILITY CLASSES ARE B = A/B, D = C/D, E = E, AND F = F

WIND SPEED INTERVALS ARE IN METERS PER SECOND, 1 (0-1), 2 (1-2), 3 (2-3), 4 (3-5), 5 (5-7), 6 (GT 7)

	WIND DIRECTION																	
METBIN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	TOTAL	PER CENT
1 B 3	0.000	0.000	0.042	0.167	0.104	0.146	0.083	0.083	0.042	0.021	0.042	0.042	0.021	0.104	0.104	0.000	48	0.5479
2 B 4	0.013	0.038	0.013	0.087	0.063	0.038	0.050	0.325	0.050	0.075	0.025	0.000	0.000	0.000	0.150	0.075	80	0.9132
3 D 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	1	0.0114
4 D 2	0.036	0.000	0.036	0.000	0.000	0.036	0.250	0.143	0.071	0.036	0.071	0.000	0.036	0.107	0.107	0.071	28	0.3196
5 D 3	0.029	0.057	0.057	0.057	0.057	0.029	0.257	0.029	0.143	0.057	0.000	0.000	0.029	0.086	0.086	0.029	35	0.3995
6 D 4	0.044	0.033	0.011	0.011	0.022	0.088	0.121	0.132	0.088	0.110	0.011	0.000	0.000	0.055	0.220	0.055	91	1.0388
7 D 5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.125	0.000	0.000	0.000	0.000	0.000	0.000	0.750	0.125	8	0.0913
8 D 6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	1	0.0114
9 E 1	0.027	0.012	0.018	0.017	0.011	0.008	0.013	0.014	0.027	0.090	0.232	0.235	0.162	0.066	0.040	0.027	1419	16.1986
10 E 2	0.038	0.031	0.038	0.047	0.040	0.040	0.036	0.040	0.056	0.112	0.140	0.074	0.086	0.103	0.072	0.048	2673	30.5137
11 E 3	0.073	0.052	0.058	0.046	0.035	0.026	0.059	0.108	0.095	0.108	0.054	0.025	0.036	0.057	0.097	0.071	1656	18.9041
12 E 4	0.165	0.087	0.081	0.045	0.030	0.014	0.053	0.142	0.107	0.045	0.019	0.001	0.000	0.007	0.101	0.103	1130	12.8995
13 F 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.083	0.167	0.333	0.250	0.083	0.000	0.083	12	0.1370
14 F 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.179	0.179	0.071	0.286	0.107	0.107	0.071	28	0.3196
15 F 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.714	0.143	0.143	0.000	7	0.0799
17 R1 3	0.073	0.055	0.029	0.015	0.036	0.015	0.069	0.069	0.073	0.069	0.080	0.080	0.080	0.055	0.098	0.105	275	3.1393
18 R1 8	0.051	0.030	0.010	0.071	0.010	0.010	0.040	0.091	0.061	0.111	0.061	0.101	0.121	0.111	0.081	0.040	99	1.1301
19 R1 16	0.058	0.065	0.029	0.036	0.029	0.007	0.087	0.058	0.036	0.058	0.116	0.123	0.094	0.058	0.094	0.051	138	1.5753
20 R1 32	0.062	0.022	0.031	0.022	0.040	0.022	0.018	0.058	0.075	0.071	0.115	0.058	0.053	0.111	0.146	0.097	226	2.5799
21 R1 64	0.081	0.064	0.034	0.050	0.027	0.013	0.013	0.057	0.074	0.037	0.084	0.101	0.084	0.091	0.104	0.087	298	3.4018
22 R2 3	0.103	0.029	0.015	0.059	0.015	0.059	0.074	0.074	0.074	0.088	0.044	0.074	0.029	0.074	0.118	0.074	68	0.7763
23 R2 8	0.083	0.167	0.000	0.000	0.083	0.000	0.167	0.000	0.167	0.083	0.083	0.167	0.000	0.000	0.000	0.000	12	0.1370
24 R2 16	0.050	0.100	0.000	0.050	0.050	0.000	0.200	0.000	0.000	0.100	0.050	0.050	0.100	0.000	0.050	0.200	20	0.2283

25 R2 32	0.139	0.083	0.083	0.000	0.000	0.028	0.083	0.028	0.056	0.083	0.028	0.139	0.000	0.083	0.083	0.083	36	0.4110
26 R2 64	0.110	0.041	0.068	0.027	0.041	0.055	0.000	0.041	0.055	0.082	0.110	0.096	0.123	0.027	0.041	0.082	73	0.8333
27 R3 3	0.174	0.130	0.000	0.000	0.000	0.043	0.087	0.043	0.087	0.043	0.043	0.000	0.000	0.043	0.087	0.217	23	0.2626
28 R3 8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1	0.0114
29 R3 16	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.167	0.000	6	0.0685
30 R3 32	0.000	0.000	0.000	0.000	0.000	0.125	0.250	0.250	0.000	0.000	0.000	0.000	0.000	0.125	0.125	0.125	8	0.0913
31 R3 64	0.000	0.059	0.000	0.000	0.059	0.000	0.000	0.059	0.000	0.294	0.235	0.059	0.000	0.176	0.000	0.059	17	0.1941
32 R4 3	0.164	0.049	0.213	0.033	0.000	0.000	0.098	0.098	0.049	0.016	0.033	0.049	0.016	0.049	0.082	0.049	61	0.6963
33 R4 8	0.000	0.091	0.000	0.000	0.091	0.091	0.000	0.000	0.000	0.182	0.000	0.091	0.000	0.091	0.091	0.273	11	0.1256
34 R4 16	0.115	0.115	0.115	0.115	0.000	0.000	0.038	0.000	0.038	0.000	0.038	0.038	0.115	0.115	0.077	0.077	26	0.2968
35 R4 32	0.075	0.094	0.226	0.057	0.000	0.000	0.019	0.019	0.000	0.019	0.057	0.094	0.113	0.075	0.075	0.075	53	0.6050
36 R4 64	0.120	0.130	0.098	0.033	0.000	0.000	0.000	0.000	0.011	0.022	0.065	0.065	0.141	0.098	0.098	0.120	92	1.0502
37 ALL	0.066	0.044	0.045	0.040	0.031	0.026	0.043	0.069	0.066	0.089	0.109	0.081	0.075	0.070	0.083	0.063	8760	

WIND DIRECTION

METBIN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	TOTAL	PER CENT
1 B 3	0	0	2	8	5	7	4	4	2	1	2	2	1	5	5	0	48	0.5479
2 B 4	1	3	1	7	5	3	4	26	4	6	2	0	0	0	12	6	80	0.9132
3 D 1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0.0114
4 D 2	1	0	1	0	0	1	7	4	2	1	2	0	1	3	3	2	28	0.3196
5 D 3	1	2	2	2	2	1	9	1	5	2	0	0	1	3	3	1	35	0.3995
6 D 4	4	3	1	1	2	8	11	12	8	10	1	0	0	5	20	5	91	1.0388
7 D 5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	6	1	8	0.0913
8 D 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0.0114
9 E 1	39	17	26	24	15	11	18	20	38	128	329	334	230	94	57	39	1419	16.1986
10 E 2	101	83	101	125	107	107	97	107	151	300	373	197	229	275	192	128	2673	30.5137
11 E 3	121	86	96	77	58	43	98	179	158	179	90	41	59	94	160	117	1656	18.9041
12 E 4	187	98	92	51	34	16	60	160	121	51	21	1	0	8	114	116	1130	12.8995
13 F 1	0	0	0	0	0	0	0	0	0	1	2	4	3	1	0	1	12	0.1370
14 F 2	0	0	0	0	0	0	0	0	0	5	5	2	8	3	3	2	28	0.3196
15 F 3	0	0	0	0	0	0	0	0	0	0	0	0	5	1	1	0	7	0.0799
16 F 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
17 R1 3	20	15	8	4	10	4	19	19	20	19	22	22	22	15	27	29	275	3.1393
18 R1 8	5	3	1	7	1	1	4	9	6	11	6	10	12	11	8	4	99	1.1301
19 R1 16	8	9	4	5	4	1	12	8	5	8	16	17	13	8	13	7	138	1.5753
20 R1 32	14	5	7	5	9	5	4	13	17	16	26	13	12	25	33	22	226	2.5799
21 R1 64	24	19	10	15	8	4	4	17	22	11	25	30	25	27	31	26	298	3.4018
22 R2 3	7	2	1	4	1	4	5	5	5	6	3	5	2	5	8	5	68	0.7763
23 R2 8	1	2	0	0	1	0	2	0	2	1	1	2	0	0	0	0	12	0.1370
24 R2 16	1	2	0	1	1	0	4	0	0	2	1	1	2	0	1	4	20	0.2283
25 R2 32	5	3	3	0	0	1	3	1	2	3	1	5	0	3	3	3	36	0.4110

26	R2	64	8	3	5	2	3	4	0	3	4	6	8	7	9	2	3	6	73	0.8333
27	R3	3	4	3	0	0	0	1	2	1	2	1	1	0	0	1	2	5	23	0.2626
28	R3	8	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.0114
29	R3	16	0	0	0	0	2	0	0	3	0	0	0	0	0	0	1	0	6	0.0685
30	R3	32	0	0	0	0	0	1	2	2	0	0	0	0	0	1	1	1	8	0.0913
31	R3	64	0	1	0	0	1	0	0	1	0	5	4	1	0	3	0	1	17	0.1941
32	R4	3	10	3	13	2	0	0	6	6	3	1	2	3	1	3	5	3	61	0.6963
33	R4	8	0	1	0	0	1	1	0	0	0	2	0	1	0	1	1	3	11	0.1256
34	R4	16	3	3	3	3	0	0	1	0	1	0	1	1	3	3	2	2	26	0.2968
35	R4	32	4	5	12	3	0	0	1	1	0	1	3	5	6	4	4	4	53	0.6050
36	R4	64	11	12	9	3	0	0	0	0	1	2	6	6	13	9	9	11	92	1.0502

* * * * SUMMARIES * * * *

R	125	91	76	54	42	27	69	89	91	95	126	129	120	121	152	136	1543	17.6142
B	1	3	3	15	10	10	8	30	6	7	4	2	1	5	17	6	128	1.4612
D	6	5	4	3	4	10	27	18	15	14	3	0	2	11	33	9	164	1.8721
E	448	284	315	277	214	177	273	466	468	658	813	573	518	471	523	400	6878	78.5160
F	0	0	0	0	0	0	0	0	0	6	7	6	16	5	4	3	47	0.5365
1	39	17	26	24	15	11	18	20	38	130	331	338	233	95	57	40	1432	16.3470
2	102	83	102	127	107	112	104	111	153	306	381	199	238	282	198	132	2737	31.2443
3	122	88	100	85	65	47	111	184	165	182	91	43	66	102	169	118	1738	19.8402
4	181	89	85	47	38	27	74	181	118	60	23	1	0	13	140	124	1201	13.7100
5	11	15	7	12	3	0	1	18	15	7	1	0	0	0	12	3	105	1.1986
6	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	1	4	0.0457

DCD/NEDO-33201 Impact

No DCD changes will be made in response to this RAI.

A sensitivity study will be added to Section 10 of NEDO-33201, Rev 2.

NRC RAI 19.2-79

The assumption of ground level releases with thermal content equivalent to ambient is conservative for early fatalities, but non-conservative for population dose and latent fatalities. Provide an assessment of the sensitivity of risk results to alternative assumptions regarding release elevation and energy of release.

GEH Response

The sensitivity of the risk results with elevation and energy of release is studied Section 10.5, of Chapter 10 of NEDO-33201, revision 2.

The results of the sensitivity study are compared with the three risk goals stated in Chapter 10.4 of NEDO-33201.

To consider uncertainty and margin, a design goal one order of magnitude lower than all three risk goals is proposed in Chapter 10 of NEDO-33201 as the ESBWR radiological consequence design goals.

The sensitivity study shows that the Chapter 10 base case with ground release without buoyant energy rise is conservative for individual risk evaluation at the site boundary.

Overall, the sensitivity study indicates that an elevated release with buoyant energy rise, the radiological consequence risk results do not change significantly as far as meeting the three risk goal.

As such, it is reasonable to conclude that the base case presented in NEDO-33201, Chapter 10 represents adequate risk insights to measure against the three risk goals.

DCD/NEDO-33201 Impact

No specific DCD changes will be made in response to this RAI.

A sensitivity study will be added to Chapter 10 of NEDO-33201.