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

Subject: **Beaver Valley Power Station, Unit No. 2**
Docket No. 50-412, License No. NPF-73
Response to NRC Request for Additional Information (RAI),
BVPS Unit 2 IPEEE

References:

1. NRC letter to DLC dated July 28, 1998, Request for Additional Information (RAI) Regarding IPEEE for BVPS, Unit No. 2 (TAC No. M83591)

2. DLC letter to NRC, Request for Additional Information (RAI), BVPS Unit 2 IPEEE Response Date Extension (L-98-184 dated September 17, 1998)

The attachment provides the Beaver Valley Power Station, Unit No. 2 response to NRC letter dated July 28, 1998 (Reference 1) which requested additional information regarding the Individual Plant Examination of External Events (IPEEE) for Beaver Valley Power Station Unit No. 2.

The response was requested within 60 days; however, a request for an extension of an additional 45 days for the response was provided per Reference 2.

Questions concerning this response may be directed to Mr. M. S. Ackerman, Manager, Safety & Licensing at (412) 393-5203.

Sincerely,

Sushil C. Jain

A011

c: Mr. D. S. Brinkman, Sr. Project Manager
Mr. D. M. Kern, Sr. Resident Inspector
Mr. H. J. Miller, NRC Region I Administrator

DELIVERING QUALITY ENERGY

ATTACHMENT

RESPONSE TO NRC RAI ON BEAVER VALLEY UNIT 2 IPEEE

RESPONSE TO NRC RAI ON BEAVER VALLEY UNIT 2 IPEEE

Fire Events:

Request 1.

It is important that the human error probabilities (HEPs) used in the detailed analysis phase of a fire PRA properly reflect the potential effects of fire (e.g., smoke, heat, and loss of lighting), even if these effects do not directly cause equipment damage in the scenarios being analyzed. If these effects are not treated, the HEPs may be optimistic and result in incorrect quantification of unscreened scenarios. Please note that HEPs which are conservative with respect to an internal events probabilistic analysis could be non-conservative with respect to a fire risk analysis.

The submittal does not indicate whether or not fire impacts were included in the assessment of human actions in the final quantification. Please identify: a) the HEPs credited in the final quantification including recovery actions (descriptions and numerical values), and b) how the effects of the postulated fires were treated in calculating the HEPs and recovery actions.

Response to Request 1.

The HEPs developed for the IPE were used as-is for the fire analysis, with the exception of the operator action to recover offsite power. Offsite power recovery was failed for all fire scenarios. In addition, five new operator actions were evaluated specifically as recovery actions for fire scenarios and are credited in the detailed fire analysis (see attached Table 1-1 Operator Actions for: ZHECB1, ZHECB2, ZHECB6, ZHECT1 and ZHESB8).

The methodology applied to evaluate the new human actions necessary for recovery in the fire analysis is the same as that applied in the IPE studies (i.e., success likelihood index methodology). The quantitative evaluation of the HEP is accomplished by assessment teams made up of a nuclear shift supervisor, an operator, an SRO training instructor, and PRA team members who rank the performance-shaping factors (PSF) against two criteria:

- Relative importance (or weight) of the effect of each PSF on the likelihood of the success of the action.
- Degree to which the PSF helps or hinders the operator in the performance of the action.

The descriptions of the recovery actions shown in attached Table 1-1 were compared against the Unit 1 human recovery actions for fires, which were evaluated using the above methodology during the BVPS-1 IPEEE assessment. Based on the similarities of available procedures, operator training and the station's general response to a plant fire, the HEP values for BVPS-2 were obtained by using the BVPS-1 "Fire-Specific Operator Recovery Action" HEP analysis. For a fire in area CB-1, CB-2, CB-6 or CT-1 (where the operators have to evacuate the control room) operators are required to activate the same safe shutdown procedure, 2OM-56C.4 "Alternate Safe Shutdown from Outside Control Room". Since most of the recovery actions for these fire initiators are identical, the HEP values were conservatively selected to be the same as the highest BVPS-1 value, i.e., 5.10E-02. For a fire in SB-8, where the purple train DC power number 2 battery is located, operators do not have to evacuate the control room. However, due to the required recovery actions that are spread in many areas throughout the plant, there would be an additional stress on the operator. Therefore, the HEP value was again conservatively selected to be the highest value of 5.10E-02 from the BVPS-1 HEP analysis. These five recovery HEPs were credited in the detailed fire analysis as shown on Table 4-11 (column $F_{NR,\,i}$) of the BVPS-2 IPEEE submittal.

Attached Table 1-2 lists the HEPs identified from the IPE analysis which were re-examined to determine if the HEPs are still applicable to the IPEEE model with respect to the fire scenarios. If an operator action is affected by a postulated fire scenario, then the action was conservatively assumed to be guaranteed failed in the final quantification. Table 1-2 summarizes four categories of fire impacts on HEPs:

1) For operator actions performed from a remote location away from the fire area or from the control room, no changes to the HEPs were deemed necessary, since the fire will have an insignificant impact on the operators' ability to perform the action as addressed in IPE.
2) For operator actions performed in the area where the fire is occurring, no changes to the HEPs were deemed necessary, since fires impacting the equipment in a fire zone negate any possible operator recovery action involving that equipment.
3) For operator actions performed in a fire zone adjacent to or near the fire zone where the fire is occurring, no change was deemed necessary to the HEPs as long as two or more paths are available for the operators to reach the fire zone where the recovery action is performed.
4) For operator actions performed in a fire zone adjacent to or near the fire zone where the fire is occurring and with only one path available for operator, a reevaluation of the HEPs would be needed to determine the potential affect in the final quantification. No operator actions fitting this last category were identified for BVPS-2.

For the reasons given in the above descriptions of the four categories of fire impacts on operator actions, it was concluded that no changes were necessary to the existing IPE HEPs for the fire analysis.

Table 1-1. HEPs For The BVPS-2 Fire-Specific Operator Recovery Actions			
HEP Identifier	**HEP Value**	**Required Operator Action**	**HEP Affects From IPEEE Fire Scenarios**
ZHECB1	5.10E-02	Operator follows the Alternate Safe Shutdown Procedure 2OM-56C, locally start and align the auxiliary feedwater pump, locally control the atmospheric steam dump valves and manually start the No. 1 DG to provide power for the orange train safe shutdown equipment, given a fire in the Instrumentation and Relay Room (CB-1) that propagates to the Cable Tunnel (CT-1)	HEP has been credited in the detailed fire analysis [see Table 4-11 (column $F_{NR,\ i}$) of the IPEEE submittal]
ZHECB2	5.10E-02	Operator follows the Alternate Safe Shutdown Procedure 2OM-56C, locally start and align the auxiliary feedwater pump, locally control the atmospheric steam dump valves and manually start the No. 1 DG to provide power for the orange train safe shutdown equipment, given a fire in the Cable Spreading Room (CB-2) that propagates to the Cable Tunnel (CT-1)	HEP has been credited in the detailed fire analysis [see Table 4-11 (column $F_{NR,\ i}$) of the IPEEE submittal]
ZHECB6	5.10E-02	Operator follows the Alternate Safe Shutdown Procedure 2OM-56C, locally recover the orange train emergency power, start and align the safe shutdown equipment, given a fire in the West Communication Room (CB-6)	HEP has been credited in the detailed fire analysis [see Table 4-11 (column $F_{NR,\ i}$) of the IPEEE submittal]
ZHECT1	5.10E-02	Operator follows the Alternate Safe Shutdown Procedure 2OM-56C, locally start and align the auxiliary feedwater pump, locally control the atmospheric steam dump valves and manually start the No. 1 DG to provide power for the orange train safe shutdown equipment, given a fire in the Cable Tunnel (CT-1)	HEP has been credited in the detailed fire analysis [see Table 4-11 (column $F_{NR,\ i}$) of the IPEEE submittal]
ZHESB8	5.10E-02	Operators manually start and align the orange train shutdown equipment from the control room and locally throughout the plant, given a fire in the DC Battery 2-2 room (SB-8)	HEP has been credited in the detailed fire analysis [see Table 4-11 (column $F_{NR,\ i}$) of the IPEEE submittal]

Table 1-2 (Sheet 1 of 4). HEPs Identified From The BVPS-2 IPE Analysis			
HEP Identifier	**HEP Value**	**Required Operator Action**	**HEP Affects From IPEEE Fire Scenarios**
ZHEAF1	2.00E-02	Operator locally align SWS water to AFW pumps suction, when PDWST tank [2FWE-TK210] is not available	No change to the HEP, since more than one path is available
ZHEAF3	3.43E-04	Operator aligns gravity feed makeup from DWST [2WTD-TK23] to [2FWE-TK210]	No change to the HEP, since more than one path is available
ZHECC1	3.31E-03	Operator locally align and start the standby CCP pump from control room on loss of running and auto standby pumps	No change to the HEP, since more than one path is available
ZHECC2	6.44E-03	Operator locally align standby CCP heat exchanger to operable SWS train	No change to the HEP, since more than one path is available
ZHECD1	8.75E-04	Operator cool down RCS by Atmos Steam Dump Valves from control room	No change to the HEP, since action is performed in control room
ZHECD2	4.86E-03	Operator cool down RCS by locally open Atmos Steam Dump Valves	No change to the HEP, since more than one path is available
ZHECD5	1.95E-02	Operator cool down RCS by locally open Atmos Steam Dump Valves during a station blackout	No change to the HEP, since more than one path is available
ZHECD6	7.10E-02	Operator cool down RCS by Atmos Steam Dump Valves from control room during small LOCA & HHSI failed	No change to the HEP, since action is performed in control room
ZHECD7	1.49E-01	Operator cool down RCS by locally open Atmos Steam Dump Valves during a small LOCA & HHSI failed	No change to the HEP, since more than one path is available
ZHECI1	7.43E-03	Operator locally close RCP seal return isolation valve [2CHS-MOV381] on loss all AC power	No change to the HEP, since more than one path is available
ZHECI2	4.88E-04	Isolate Cnmt. vents/drains by placing pumps in pull-to-lock from control room	No change to the HEP, since action is performed in control room
ZHECS1	2.00E-02	Operator locally align standby CCS heat exchanger following a CIA signal	No change to the HEP, since more than one path is available
ZHECS2	9.26E-02	Operator locally align filtered water supply to the station air compressors following a loss of CCS	No change to the HEP, since more than one path is available
ZHEHH1	3.39E-03	Operator locally align AC power to standby HHSI pump	No change to the HEP, since more than one path is available
ZHEHH2	6.12E-04	Fails to properly monitor plant parameters and prematurely secure SI from control room	No change to the HEP, since action is performed in control room

Table 1-2 (Sheet 2 of 4). HEPs Identified From The BVPS-2 IPE Analysis			
HEP Identifier	**HEP Value**	**Required Operator Action**	**HEP Affects From IPEEE Fire Scenarios**
ZHEMU1	5.97E-03	Provide makeup water to the RWST from control room	No change to the HEP, since action is performed in control room
ZHEMU2	5.71E-03	Provide makeup water to the RWST from spent fuel pool during small LOCA	No change to the HEP, since more than one path is available
ZHEOB1	4.26E-03	Operator initiate RCS bleed & feed by opening PORVs from control room	No change to the HEP, since action is performed in control room
ZHEOB2	3.89E-02	Operator initiate RCS bleed & feed by opening PORVs from control room after AFW failure	No change to the HEP, since action is performed in control room
ZHEOD1	1.11E-03	Depressurize RCS by using pressurizer spray/PORVs from control room	No change to the HEP, since action is performed in control room
ZHEOF1	1.20E-03	Operator reestablishes main feedwater following a safety injection signal	No change to the HEP, since action is performed in control room
ZHEOF2	2.86E-04	Operator reestablishes main feedwater with no safety injection signal	No change to the HEP, since action is performed in control room
ZHEOR1	1.37E-03	Operator manually initiate recirculation mode of operation from control room	No change to the HEP, since action is performed in control room
ZHEOS1	1.06E-02	Manually actuates SI & AFW on loss of SSPS from control room	No change to the HEP, since action is performed in control room
ZHEOS2	1.70E-02	Manually actuates SI on loss of SSPS from control room with small LOCA present	No change to the HEP, since action is performed in control room
ZHEOS6	1.00E-03	Manually actuates AFW and verifies operation on loss of SSPS from control room	No change to the HEP, since action is performed in control room
ZHEPI1	4.34E-04	Operator isolates stuck open PORV(s) with block valves from control room	No change to the HEP, since action is performed in control room
ZHEPR1	1.0E+00	Operator terminates HHSI before PORV water relief - ISI	No change to the HEP, since action is performed in control room
ZHERE1	5.00E-03	Operator reenergizes emergency AC buses, seal LOCA with AFW available	No change to the HEP, since action is performed in control room
ZHERE2	1.21E-01	Operator reenergizes emergency AC buses, PORV LOCA with AFW available	No change to the HEP, since action is performed in control room
ZHERE3	8.13E-02	Operator reenergizes emergency AC buses, seal LOCA with AFW failed	No change to the HEP, since action is performed in control room
ZHERE4	1.36E-01	Operator reenergizes emergency AC buses, PORV LOCA with AFW failed	No change to the HEP, since action is performed in control room

Table 1-2 (Sheet 3 of 4). HEPs Identified From The BVPS-2 IPE Analysis

HEP Identifier	HEP Value	Required Operator Action	HEP Affects From IPEEE Fire Scenarios
ZHERE5	7.56E-03	Operator recover both trains of fast transfer breakers with diesel generator failures	No change to the HEP, since the fire analysis conservatively assumed normal electric power recovery is failed
ZHERE6	4.91E-02	Operator recover both trains of fast transfer breakers with a PORV LOCA and diesel generator failures	No change to the HEP, since the fire analysis conservatively assumed normal electric power recovery is failed
ZHERE7	2.39E-02	Operator restore offsite power, seal LOCA with AFW available	No change to the HEP, since the fire analysis conservatively assumed normal electric power recovery is failed
ZHERE8	2.04E-02	Operator reenergizes emergency AC buses, PORV LOCA with AFW available and HR=F	No change to the HEP, since action is performed in control room
ZHERE9	1.15E-02	Operator reenergizes emergency AC buses, seal LOCA with AFW available and CD=F	No change to the HEP, since action is performed in control room
ZHEREA	1.36E-01	Operator recover one emergency AC buss, PORV LOCA with AFW available	No change to the HEP, since action is performed in control room
ZHERED	4.45E-04	Operator recover both trains of fast transfer breakers with no breaker replacement	No change to the HEP, since the fire analysis conservatively assumed normal electric power recovery is failed
ZHEREE	2.65E-03	Operator recover both trains of fast transfer breakers with PORV LOCA, no breaker replacement	No change to the HEP, since the fire analysis conservatively assumed normal electric power recovery is failed
ZHEREH	2.00E-02	Operator recover both emergency DGs, seal LOCA with AFW available	No change to the HEP, since action is performed in control room
ZHESE1	5.29E-03	Operator trips the RCPs on loss of CCP to thermal barrier, motor bearing and lube oil coolers	No change to the HEP, since action is performed in control room
ZHESM1	5.47E-02	Operator stops RSS pumps, QSS failed, SLOCA	No change to the HEP, since action is performed in control room
ZHETB2	1.11E-02	Operator resets CIA signal and restores CCP flow to IAC	No change to the HEP, since action is performed in control room
ZHEWA1	7.89E-02	Operator manually starts SWS pump and align SWS cooling to diesel generator	No change to the HEP, since action is performed in control room

Table 1-2 (Sheet 4 of 4). HEPs Identified From The BVPS-2 IPE Analysis			
HEP Identifier	**HEP Value**	**Required Operator Action**	**HEP Affects From IPEEE Fire Scenarios**
ZHEWA2	3.08E-02	Operator manually starts auxiliary SWS pump and align to SWS header	No change to the HEP, since action is performed in control room
ZHEWA3	7.89E-02	Operator manually starts standby SWS pump during Loss of Offsite Power	No change to the HEP, since action is performed in control room
ZHEXT1	5.00E-02	Operator crosstie station emergency diesel generator, general transients	No change to the HEP, since more than one path is available
ZHEXT2	1.00E-01	Operator crosstie station emergency diesel generator, SLOCA	No change to the HEP, since more than one path is available

Request 2.

NUREG-1407, Section 4.2 and Appendix C, and GL 88-20, Supplement 4, request that documentation be submitted with the IPEEE submittal with regard to the Fire Risk Scoping Study (FRSS) issues, including the basis and assumptions used to address these issues, and a discussion of the findings and conclusions. NUREG-1407 also requests that evaluation results and potential improvements be specifically highlighted. Control system interactions involving a combination of fire-induced failures and high probability random equipment failures were identified in the FRSS as potential contributors to fire risk.

The issue of control systems interactions is associated primarily with the potential that a postulated fire in a fire area (e.g., the main control room (MCR)) might lead to potential degradation of safety system redundancy due to hidden design vulnerabilities of control systems. Given an MCR fire, the likely sources of control systems interactions could happen between the MCR, the remote shutdown panel (RSP), and shutdown systems. Specific areas that have been identified as requiring attention in the resolution of this issue include:

(a) *Electrical independence of the remote shutdown control systems: The primary concern of control systems interactions occurs at plants that do not provide independent remote shutdown control systems. The electrical independence of the remote shutdown panel and the evaluation of the level of indication and control of remote shutdown control and monitoring circuits need to be assessed.*

(b) *Loss of control equipment or power before transfer: The potential for loss of control power for certain control circuits as a result of hot shorts and/or blown fuses before transferring control from the MCR to remote shutdown locations needs to be assessed.*

(c) *Spurious actuation of components leading to component damage, loss-of-coolant accident (LOCA), or interfacing systems LOCA: The spurious actuation of one or more safety-related to safe-shutdown-related components as a result of fire-induced cable faults, hot shorts, or component failures leading to component damage, LOCA, or interfacing systems LOCA, prior to taking control from the remote shutdown panel, needs to be assessed. This assessment also needs to include the spurious starting and running of pumps as well as the spurious repositioning of valves.*

(d) *Total loss of system function: The probability of total loss of system function as a result of redundant train (and/or component) failures or electrical distribution system (power source) failure during a fire needs to be addressed.*

Please describe the BVPS-2 remote shutdown control system capability, including the nature and location of the shutdown station(s), as well as the types of control actions which can be taken from the remote shutdown panel(s). Please describe how plant procedures provide for transfer of control to the remote shutdown panels. Please provide an evaluation of whether loss of control power due to hot shorts and/or blown fuses could occur prior to transferring control to the remote shutdown location and identify the core damage frequency (CDF) contribution of these types of failures. If these failures have been screened in the IPEEE, please provide the basis for the

screening. Finally, please provide an evaluation of whether spurious actuation of components as a result of fire-induced cable faults, hot shorts, or component failures could lead to component damage, a LOCA, or an interfacing systems LOCA prior to taking control from the RSP (considering both spurious starting and running of pumps as well as the spurious repositioning of valves).

Response to Request 2.

The results of the BVPS-2 IPEEE Control Room Evacuation Analysis indicated that assuming the worst case control room fire, the accumulation of smoke still allows approximately 8 to 10 minutes, depending on the growth rate of the fire, for the operators to perform actions before evacuating the control room. Procedures exist for bringing the unit to hot shutdown from outside the control room using the emergency shutdown panel (SDP) located on the bottom floor of the control building (CB-6) and procedure 2OM-53C.4, AOP 2.33.1A "Control Room Inaccessibility." This procedure instructs the operators to manually trip the reactor, verify turbine/generator trip and then transfer control of safe shutdown equipment to the SDP for a small control room fire (e.g., heavy smoke or other hazards requiring evacuation as ordered by the Nuclear Shift Supervisor). The IPEEE control room fire analysis did not take credit for the SDP.

For a major uncontrolled fire in the control room and without the SDP, Procedure 2OM-56C.4 "Alternate Safe Shutdown From Outside Control Room" would be used. This procedure instructs the operators to manually trip the reactor; any additional actions that can be completed from within the control room only aid in the safe shutdown following a control room evacuation. The Alternate Shutdown Panel (ASP) is located in the Primary Auxiliary Building (PA-4). Table 2-1 below lists the ASP safety shutdown equipment controls and indications:

Table 2-1 (Sheet 1 of 2). BVPS-2 Alternate Shutdown Panel Equipment Control And Indications

Equipment Mark Number	Description
ACB-2A10	4KV Bus 2A to Emergency Bus 2AE
ACB-42A	2A System Station Service Transformer to 4KVS Bus 2A
ACB-2E7	Bus 2AE emergency supply breaker
ACB-2E10	Emergency diesel generator supply breaker
2CHS-FCV122	Charging Pumps Discharge Flow Control Valve
2CHS-LCV115B	Charging pump suction valve from RWST
2CHS-P21A	Charging pump
2CHS-P22A	Boric acid transfer pump
2CCP-MOV112A	RHR heat exchanger 21A supply valve
2CCP-P21A	Primary component cooling pump
2EGS-EG2-1	Emergency diesel generator
2FWE-HCV100C	AFW feed header valve to steam generator 21B
2FWE-HCV100E	AFW feed header valve to steam generator 21A
2FWE-P23A	Steam generator auxiliary feed water pump

Table 2-1 (Sheet 2 of 2). BVPS-2 Alternate Shutdown Panel Equipment Control And Indications	
Equipment Mark Number	**Description**
2RCS-PCV456	Pressurizer power relief valve (PORV)
2RHS-P21A	RHR pump
2RHS-MOV701A	RHR supply isolation valve
2RHS-MOV702A	RHR supply isolation valve
2RHS-MOV720A	RHR return isolation valve
2SVS-PCV101A	Atmospheric steam dump valve to steam generator 21A
2SVS-PCV101B	Atmospheric steam dump valve to steam generator 21B
2SWS-P21A	Service water pump
2SWS-MOV102A	Service water pump discharge valve
2SWS-MOV113A	DG heat exchanger service water header valve
2FWE-FI100AF	Steam generator auxiliary feed line flow indication
2FWE-FI100BF	Steam generator auxiliary feed line flow indication
2FWS-LI477F	Steam generator 21A level indication
2FWS-LI487F	Steam generator 21B level indication
2MSS-PI475F	Steam generator 21A pressure indication
2MSS-PI485F	Steam generator 21B pressure indication
2RCS-LI459AF	Pressurizer level indication
2RCS-PI403F	RCS pressure indication
2RCS-PI455F	Pressurizer pressure indication
2RCS-TI413F	RCS hot leg temperature indication
2RCS-TI423F	RCS hot leg temperature indication
2RCS-TI410F	RCS cold leg temperature indication
2RCS-TI420F	RCS cold leg temperature indication

Since shutdown procedures can be instituted from outside the main control room and with a limited amount of fuel consumed, there should always be sufficient time for the operators to react to the fire and extinguish it before evacuation becomes necessary. The only time that evacuation would be necessary is when a very large amount of fuel is rapidly consumed, which has a conditional probability of 0.128%. Since the chances of actually having to evacuate the control room are small, it was deemed that development of scenarios involving control room evacuation were not necessary.

A conservative approach was taken in the treatment of fire damage to cables. No differentiation was made between hot shorts and open circuits when cables were impacted by fires. The worst impact, from either hot shorts or open circuits, on the component supplied/controlled by the cable was assumed. Therefore, hot shorts that would cause equipment to be unavailable when required are accounted for in the IPEEE fire analysis. The following Table 2-2 lists the impacts assumed in the IPEEE fire analysis for various types of equipment and failure modes when any cable associated with the equipment is damaged by fire.

Table 2-2. Equipment Failure Modes Damaged By Fire			
Component	Normal Condition	Required Condition	Modeled As
Pump/Compressor/ Fan	Running	Running	Fail during operation
Pump/Compressor/ Fan	Standby	Running	Fail to start
MOV/AOV/SOV	Closed/Open	Open/Closed	Fail on demand
MOV/AOV/SOV	Open	Open	Transfer closed
PORV	Closed	Open Reclose	Fail to reclose (1)
Diesel Generator	Standby	Running	Fail to start
Bus/MCC/Xfmr	Operating	Operating	Fail during operation
Circuit Breaker	Closed/Open	Open/Closed	Fail on demand
Circuit Breaker	Open/Closed	Open/Closed	Transfer closed/open
MO/AO Damper	Closed/Open	Open/Closed	Fail on demand
MO/AO Damper	Open/Closed	Open/Closed	Transfer closed/open
Transmitter	Operating	Operating	Fail during operation
Transmitter	Standby	Operating	Fail on demand
Switch	Standby	Operating	Fail on demand
Battery Charger/Inverter	Operating/Standby	Operating	Fail during operation
(1) PORVs are assumed to be stuck open for any fire that damages PORV cables (i.e., resulting in a small LOCA)			

As noted in the above table, a small LOCA via a stuck-open PORV was assumed anytime that a fire damaged a PORV cable. In addition, during the fire analysis, the possibility of a fire causing an interfacing systems LOCA (ISLOCA) was examined. Only one penetration is modeled in the frequency development for the ISLOCA (VSX) initiating event. All other penetrations were screened out for one or more of the following reasons: (1) Three pressure boundaries exist, including at least one check valve; (2) The line is small and a leak through the line is less than the makeup capability of the charging system; (3) The piping is designed for high pressure; (4) The piping inside containment is low pressure and is protected by a relief valve inside containment; or (5) The pipe path is administratively isolated (MOVs are closed with power removed). The pipe path that is modeled consists of three lines, each with two check valves in series, inside containment. The three pipe paths are headered together and there is a normally open MOV (isolation valve) outside containment. Since a fire could, at most, impact the MOV which is normally open and modeled for 'fail to close' in the initiating event frequency development, it was judged that a fire leading to an interfacing systems LOCA is insignificant.

As noted in the BVPS-2 IPE Summary Report, Section 3.1.3.6, one path that is significant at other plants for causing an ISLOCA is the RHR hot leg suction valves. However, this is not applicable to Beaver Valley Unit 2 since the RHR system is located entirely inside containment.

Since the worst impact is assumed for fires that damage cables (i.e., control cables), the impacts from hot shorts that would cause equipment to start or valves to change to the required position, before they are needed, are included implicitly in the BVPS-2 IPEEE fire analysis.

Request 3.

The BVPS-2 fire PRA uses two factors to estimate fire-induced component fragilities: the severity factor and geometric factor. The severity factor is used to estimate the fire-induced damage probability of a component due to component-induced fires. Generic fire data and engineering judgement were used to develop curves depicting the probability of component damage as a function of the distance from the fire source. The geometric factor is used to estimate the probability of component damage from transient fires. Multiple COMPBRN-IIIe code runs performed for the BVPS-2 PRA were used to establish the critical radius from the transient fire where component damage would not occur.

The response to this question submitted for BVPS-1 indicated that the data and engineering judgement used in the development of the fire severity factor are no longer available, and thus new estimates of the fire severity factors were used in a sensitivity evaluation. In addition, the use of the geometric factor was also described, and a sensitivity study was performed in which no credit was taken for the geometric factor. However, the types and sizes of transient fires used in the geometric factor evaluations were not described. Please provide this additional information concerning the development of geometric factors. In addition, repeat the sensitivity studies, performed in response to the question for BVPS-1, for BVPS-2.

Response to Request 3.

The base case point estimate total for fire scenarios is 9.53E-06, including control room fires. The geometric factor was not used for control room fires, only severity factors were used.

The geometric factor is used in one of two ways in the fire analysis. It is either a simple fraction of the fire sources in a fire zone (i.e., fraction of fire zone cable that is a source for a particular fire scenario) or it is the area fraction for human error induced fires (i.e., the fraction of the fire zone area in which the fire must be located to damage the target equipment). If no credit is taken for geometric factors resulting from COMPBRN runs, fire induced scenarios would have a total core damage frequency of 4.18E-05.

In order to evaluate the sensitivity of the fire CDF results to the severity factor, events from the PLG generic fire database were examined. The backup material from the development of the severity curves used in the IPEEE is no longer available. The fire events examined in response to this question occurred between January 1, 1980 and December 31, 1989. The review of these events was used to develop conservative severity factors that could be applied to the detailed fire scenarios to determine their sensitivity to the value of the severity factor. If the original severity factor, from the curves, was higher than the newly developed severity factor, the original severity factor was retained. For the severity factor sensitivity case postulated here, impacts "in the vicinity" of the initiating equipment are conservatively assumed to extend to a fire radius of 10 ft.

There were 30 logic cabinet fires among the fire events examined, none of which affected equipment outside the fire initiating equipment. A severity factor of 0.05 was therefore assumed in the sensitivity case for all logic cabinet fire scenarios that impacted other equipment.

There were a total of 33 mechanical equipment fires in the events examined. The description for 4 of those fires indicate that other equipment in the vicinity might be damaged. A severity factor of 0.15 for fire radii of 10 ft or less was assumed in the sensitivity case for fires initiated by pumps or HVAC fans. A severity factor of 0.05 was assumed in the sensitivity case for fire radii greater than 10 ft.

There were 22 fires in high voltage switchgear among the events examined. The description for 2 of these events indicate that they may have been severe enough to affect cables or equipment in the vicinity of the initiating switchgear. A severity factor of 0.10 for fire radii of 10 ft or less was assumed in the sensitivity case. A severity factor of 0.05 was assumed for fire radii larger than 10 ft in the sensitivity case.

There are only 6 battery charger fires in the events examined. None of these events impacted equipment outside the initiating equipment. A severity factor of 0.10 was assumed for fire radii of 10 ft or less and 0.05 for fire radii greater than 10 ft in the sensitivity case.

There are 27 fires initiated by MCCs or low voltage switchgear. None of these fires affected equipment outside the initiating equipment. A severity factor of 0.05 was assumed for fire radii of 10 ft or less and 0.02 for fire radii greater than 10 ft in the sensitivity case.

Severity factors for battery fires and cable fires were assumed to be equal to the worst case of those listed above, a severity factor of 0.15 for fire radii of 10 ft or less and 0.05 for fire radii greater than 10 ft in the sensitivity case.

These new severity factors were applied to the detailed fire subscenarios, in fire zones other than the control room, according to the required fire radius for the scenario. The severity factors were set to 1.0 for the control room fire subscenarios. The assumed severity factors are conservative for two reasons. First, the actual generic fire data implies severity factors lower than those chosen, and secondly, the required fire radius for many of the subscenarios is much greater than 10 ft, indicating that a much lower severity factor should be used. The total core damage frequency from fire scenarios, with the new severity factors applied, is 2.12E-05. It is concluded that this sensitivity case core damage result is acceptable, given the conservative nature of the severity factor values used.

Applying the new severity factors and at the same time setting the geometric factors to 1.0 yields a core damage frequency of 5.35E-05 from the fire scenarios. Changes can be made to both the geometric factors and the severity factors simultaneously since they are not both used in the same scenario.

Two fire sizes were used for the COMPBRN runs, designated small and large. Small fires were modeled using an oil pool of one gallon with a diameter of two feet. Large fires were modeled using an oil pool of ten gallons with a diameter of three feet.

Request 4.

The screening of propagation pathway boundaries on the basis of combustible contents is inappropriate for barriers rated at less than 2 hours. There is no technical justification (as supported by NUREG-1547) to allow screening of propagation pathways when the only criterion satisfied is that the estimated fire severity (in hours) is less than 50% of a rated barrier.

Please re-evaluate the propagation pathways when this criterion is eliminated for these barriers, and assess the associated impact on the fire-induced CDF results.

Response to Request 4.

There are 11 propagation paths identified for BVPS-2 that have fire barriers rated at 2 hours or less. These 11 paths are presented in Table 4-1, below. Nine of the 11 paths represent propagation to fire zones that result in no additional impacts to IPEEE modeled equipment.

Table 4-1. Propagation Paths Rated 2 Hours or Less

Fire Zone	Fire Severity (Hours)	Primary Suppression Type	Suppression Actuation Method	Adjacent Fire Zone	Path	Rating (Hours)	Note
SOB-1	2	Sprinkler	Auto.	SOB-3	Wall	1.5	No additional impacts
SOB-2	N/A	Sprinkler	Auto.	SOB-3	Wall	1.5	No additional impacts
SOB-2	N/A	Sprinkler	Auto.	TB-1	Door/Wall	1.5	
SOB-3	0.5	Sprinkler	Auto.	SOB-1	Wall	1.5	No additional impacts
SOB-3	0.5	Sprinkler	Auto.	SOB-2	Wall	1.5	No additional impacts
SOB-3	0.5	Sprinkler	Auto.	TB-1	Door/Wall	1.5	
TB-1	2	Sprinkler/CO2	Manual, Auto.	SOB-2	Wall	1.5	No additional impacts
TB-1	2	Sprinkler/CO2	Manual, Auto.	SOB-3	Wall	1.5	No additional impacts
TB-1	2	Sprinkler/CO2	Manual, Auto.	CP-1	Wall	2	No additional impacts
TB-1	2	Sprinkler/CO2	Manual, Auto.	WH-1	Wall	2	No additional impacts
TB-1	2	Sprinkler/CO2	Manual, Auto.	WH-2	Wall	2	No additional impacts

The two remaining paths are from fire zone SOB-2 to fire zone TB-1 and from SOB-3 to fire zone TB-1. Fire zone SOB-2 is the SOSB railway bay at elevation 730' and has minimal contact with TB-1. Also, no combustibles were identified in fire zone SOB-2. Therefore, propagation from SOB-2 to TB-1 is considered incredible. SOB-3 was assigned a conservative fire severity of 0.5 hours and has a barrier rated at 1.5 hours between SOB-3 and TB-1. SOB-3 also has automatic fire suppression. Even if all SOB-3 fires are assumed to propagate to TB-1 and damage all IPE equipment in TB-1, the propagation scenario would contribute approximately 1.0E-08 to the fire CDF (0.1% of the fire CDF total), with no frequency reduction factors applied. The propagation scenario from SOB-3 to TB-1 is, therefore, insignificant. The contribution to fire CDF from scenarios involving propagation paths rated 2 hours or less is also insignificant.

Request 5.

Table 4-5 in the submittal indicates that fire zones were qualitatively screened on the basis that no scram mechanisms were identified even though safety-related equipment is contained in the zone. Areas screened included portions of the intake structure, portions of the primary auxiliary building, and two battery rooms. Although a fire may not result in an automatic scram, there is a potential for a manual scram or controlled shutdown initiated by procedures or due to technical specification requirements resulting from fire-induced component damage. Please address whether a manual scram or controlled shutdown could be expected as a result of equipment failures in the zones screened by this criterion. If a scram or shutdown requirement is identified, please provide a detailed evaluation of the fire CDF of the zones that were screened using this criterion.

Response to Request 5.

Below is a table listing the 11 location scenarios that were screened in the initial quantitative screening on the basis that no reactor trip would occur due to the fire. Conditional core damage frequencies were computed for this response, assuming that a plant trip does occur. Multiplying the results by the scenario frequency we then determined the unconditional core damage frequency for each scenario.

Scenario	Fire Zone	Other FZ Impacted	Fire Frequency	Top Event Impacts	CCDF	CDF
IS-2-L-1	IS-2/IS-2	None	1.38E-03	WA*, WB*	2.03E-06	2.79E-09
AIS-L-1	AIS/AIS	None	8.47E-04	WA*, WB*	1.10E-06	9.32E-10
ER1-L-1	ER-1/ER-1	None	9.67E-03	BK*	4.39E-07	4.25E-09
ER2-L-1	ER-2/ER-2	None	8.87E-03	BK	1.21E-04	2.93E-08 (See below)
CB-5-L-1	CB-5/CB-5	None	1.21E-03	QS	4.39E-07	5.31E-10
FB-1-L-1	FB-1/FB-1	None	1.03E-03	MU	4.39E-07	4.52E-10
PA-5-L-1	PA-5/PA-5	None	1.00E-03	BK	1.21E-04	1.21E-07
SB-7-L-1	SB-7/SB-7	None	4.97E-04	IB	4.54E-07	2.26E-10
SB-9-L-1	SB-9/SB-9	None	4.97E-04	IY	6.07E-07	3.02E-10
WT-210-L-1	WT-210/WT-210	None	6.99E-05	AF	4.39E-07	3.07E-11
WT-21-L-1	WT-21/WT-21	None	1.78E-05	OR	6.36E-07	1.13E-11
					Total	**1.59E-07**
* Partial impact on top event.						

All of these scenarios, except ER2-L-1, fell below the frequency cutoff that was used for quantitative screening (i.e., 1.4E-07) and thus would have been screened from further analysis, even if a reactor trip or manual shutdown is assumed. A detailed analysis was performed on fire zone ER-2, since it was above the cutoff frequency used for quantitative screening. The total fire contribution in zone ER-2 from this detailed analysis is shown in the table above. The detailed analysis performed for ER-2 took no credit for the automatic fire detection and suppression system in ER-2.

The total frequency of the scenarios for all of the screened fire zones, without any frequency reduction factors applied (except in the case of ER-2), would add only about 1.5% to the total fire contribution to core damage frequency, if retained. Considering the conservative nature of the frequencies (i.e., no reduction factors), it is concluded that the effect of not screening these scenarios is insignificant.

Request 6.

Table 4-5 in the BVPS-2 IPEEE submittal also indicates that fire zones were qualitatively screened on the basis that no IPE equipment was identified in the fire zone. Fire zones screened include the RSP room, portions of the control building, and cable vault areas. However, it is not clear from the submittal that the IPE equipment includes all Appendix R equipment and controls. Since it is likely that fire procedures would direct the operators to use Appendix R equipment in case of a severe fire and to use the alternate shutdown panels when control room fires require evacuation of the MCR, it is important that any fire zones containing Appendix R equipment not be qualitatively screened.

Please clarify whether any of the fire zones screened by this criterion contain Appendix R equipment. If any fire zones were screened by this criterion, please provide a revised CDF evaluation of these fire zones.

Response to Request 6.

A comparison was made between the IPE equipment database and the BVPS-2 Appendix R equipment database. This comparison identified 241 components in the Appendix R database that are not included in the IPE database. These 241 components exist in 22 fire zones, six of which were screened in the initial screening process. These six screened fire zones contain 52 of the 241 components discussed above. Of these 52 components, only 5 are mentioned in Appendix R procedures, 4 emergency switchgear room fans, 2 supply and 2 exhaust, and an ASP (alternate shutdown panel) air conditioning temperature switch. Operators are instructed by the ASP activation procedure (2OM-56C.4.F-1) to start the four fans, following a control room evacuation and transfer of control to the ASP. The fans, however, are located in fire zone CV-4, which is not adjacent to the control room. A fire in zone CV-4 would not lead to an evacuation of the control room nor put procedure 2OM-56C.4.F-1 into effect. The temperature switch is located in the ASP room. The ASP ventilation startup procedure (2OM-56C.4.F-14) directs operators to start the ASP HVAC unit given a control room evacuation and transfer of control to the ASP. The HVAC unit is located in the ASP room; a fire in this zone would not lead to a control room evacuation nor put procedure 2OM-56C.4.F-14 into effect. Therefore, none of the screened fire zones containing Appendix R equipment have any impact on CDF.

Request 7.

Fires that could affect portions of both BVPS-1 and BVPS-2 were not considered. For dual-unit sites, there are three issues of potential interest. Hence, please address the following:

(a) A fire in a shared area of the BVPS facility might cause a simultaneous or a delayed demand for a trip of both units. This may complicate the response of operators to the fire event, and may create conflicting demands on plant systems which may be shared between two units. Please provide the following information regarding this issue: (1) identify all fire areas that are shared between two units and the potentially risk-important systems/components for each unit that are housed in such shared fire zones, (2) for each shared fire zone identified in (1), provide an assessment of the associated dual unit fire CDF contribution, and (3) for the special case of the MCR, assess the CDF contribution for scenarios involving a fire or smoke-induced evacuation of the MCR with subsequent shutdown of both units from the RSPs.

(b) At some dual-unit sites the safe shutdown path for a given unit may call for cross-connects to a sister unit in the event of certain fires. Hence, the fire analysis for BVPS-2 should include the unavailability of the cross-connected equipment due to outages at the sister unit (e.g., routine test and maintenance outages, and the potential that normally available equipment may be unavailable during extended refueling outages at the sister unit). Please provide the following information regarding this issue:

(1) indicate whether any fire-related safe shutdown procedures call for unit cross-connects, and,

(2) if any such cross-connects are required, determine the impact on the overall fire-induced CDF for the BVPS-2 facility if the BVPS-1 equipment is included in the assessment.

(c) Propagation of fire, smoke and suppressants between fire zones containing equipment for one unit to fire zones containing equipment for the other unit also can result in dual-unit propagation scenarios. Hence, the fire assessment for BVPS-2 should include analyses of fire scenarios addressing propagation of smoke, fire and suppressants to and from fire zones containing equipment for BVPS-1. From the information in the BVPS-2 IPEEE submittal, it is not clear whether these types of scenarios were considered and evaluated. Please clarify whether such fire propagation scenarios were addressed in the BVPS-2 IPEEE submittal. If not, please provide an evaluation of the CDF contribution of such dual-unit propagation scenarios.

Response to Request 7(a).

(1) Areas that are shared by both units are the main control room (the Unit 1 control room is separated from the Unit 2 control room by a non-rated wall with windows), the intake structure, and the alternate intake structure. In addition, Unit 1 fire zone CV-3 (cable tunnel) contains a minimal amount of non-safety Unit 2 cables as described in Appendix R, Section 3.4.18.

(2) The intake structure consists of four cubicles (A, B, C, & D) and a general area. They are designated as fire zones IS-1, IS-2, IS-3, IS-4, and IS-5, respectively. A discussion of the dual unit impact for each is provided below.

IS-1: Contains one Unit 1 river water pump, one Unit 1 raw water pump, and the motor-driven fire pump. Impact on Unit 1 is insignificant to CDF and there is essentially no impact on Unit 2 CDF.

IS-2: Contains one Unit 1 river water pump and one Unit 2 service water pump. Impact on both units is insignificant to CDF.

IS-3: Contains one Unit 1 river water pump and one Unit 2 service water pump. Impact on both units is insignificant to CDF.

IS-4: Contains one Unit 2 service water pump, one Unit 1 raw water pump, and the diesel-driven fire pump (backup to th[illegible]driven pump in IS-1). Impact on both units is insignificant to CDF.

IS-5: Contains no IPE equipment for either unit. Impact on both units is insignificant to CDF.

The alternate intake structure (fire zone AIS) contains the two auxiliary river water pumps for Unit 1 and the two standby service water pumps for Unit 2. These pumps are all standby pumps that serve as backup for the three river water pumps (Unit 1) and the three service water pumps (Unit 2) located in the intake structure. The impact of damage to all four standby pumps is insignificant to the CDF of both units.

(3) The evacuation of the control room is addressed in Appendix G of the tier 2 documentation for the IPEEE. Since shutdown of both units is possible from their respective ASPs, or even without using the ASPs, and the frequency of a fire large enough to cause evacuation of the control room is so small, the control room evacuation fire scenario was screened from further analysis and detailed subscenarios were not developed. No additional impacts arise from evacuating both control rooms simultaneously, since there are two separate operator teams and each control room has its own exit.

Response to Request 7(b).

(1) There are no fire-related procedures that call for cross-connects between the two units. There is a procedure (AOP 1.30.2 and 2.30.1) for supplying river water (Unit 1) or service water (Unit 2) loads using the diesel-driven fire pump, following a total loss of river water or service water. The supply from the diesel-driven fire pump was not credited, however, in either the IPE or the IPEEE. The emergency procedure for loss of all AC power (2OM-53A.1.ECA-0.0, step 13) directs the operators to crosstie a 4160V AC bus to the opposite unit, if available.

(2) The BVPS-2 modeling of the crosstie of 4160V AC buses between the two units accounts for the unavailability of the AC bus on BVPS-1 as a contributor to the unavailability of the crosstie. The fire analysis also takes into account the routing of cables from the Unit 1 bus to the Unit 2 bus and the impacts of fires on those cables.

Response to Request 7(c).

The control rooms for the two units are adjacent, separated only by a short wall and windows. Fires in one of the control rooms causing evacuation of both are discussed above. Propagation of fire from one control room to the other is not considered credible, since propagation of fire from one cabinet to another within the control room is not considered credible (Appendix G of tier 2 documentation).

The Unit 1 cable tunnel (fire zone CV-3) is adjacent to three Unit 2 fire zones, CB-1, CB-2, and CB-6; however, there is 2 ft of concrete separating CV-3 from the Unit 2 fire zones, making propagation of fire, smoke, or suppressants improbable.

The four cubicles in the intake structure contain both Unit 1 and Unit 2 equipment, as discussed earlier, and are located in a row from cubicle A to cubicle D. There is a 3 hour fire barrier separating the cubicles from one another. The total amount of combustibles in each cubicle converts to a fire severity of only 1/2 hour or less, making propagation of fires from one cubicle to another improbable.

Seismic Events:

Request 1.

The BVPS-2 IPEEE used the uniform hazard spectrum (UHS) as a basis for fragility quantification. This UHS has an unusual spectral shape that exhibits a pattern of consistent decrease of spectral amplitude for frequencies less than 10 Hz, and shows no spectral amplification above peak ground acceleration (PGA). The BVPS-2 IPEEE submittal seems to recognize the unrealistic shape of the UHS, compared to typical design response spectra or spectra generated from real earthquakes. The spectral shape of a seismic input plays an important role in fragility quantification. Fragility of a component is computed based on the median capacity and beta values. The spectral shape of the seismic input significantly influences computations of the median capacity, which is usually expressed as a percentage of g in PGA. Therefore, different spectral shapes should result in different fragility calculations for components that are less than rigid, and this in turn may have an impact on the evaluation of the seismic accident sequences.

(a) In examining the UHS and the hazard curves provided in the IPEEE submittal, it is noted that the UHS is cut off at 25 Hz, not the zero-period acceleration (ZPA) frequency. The ZPA of the UHS, however, may be located from the hazard curve for the 10,000-year return period and is equal to about 0.09g PGA, which is 40 percent less than the spectral amplitude at the 25 HZ cutoff frequency. If the UHS is extended to the ZPA, the spectral shape will change to one comparable to a more typical response spectra. Please discuss the impact on the fragility calculations of using the corrected spectral shape of the UHS. If numerical changes in the fragility calculations result, please discuss the effect of these changes in the fragility of applicable equipment and structures (including tanks) on the determination of the seismic accident sequences.

(b) According to Section 3.1.3 of the BVPS-2 IPEEE submittal, a new soil-structure interaction (SSI) analysis was not performed. Instead, the existing design floor spectra were scaled using the ratios of the median uniform hazard spectrum (UHS) to the design spectrum at each frequency. EPRI NP-6041-SL, Section 4 provides a guideline on scaling of In-Structure Spectra. There are two essential ingredients in the guideline. First, the ground input spectral shapes should be comparable, and second, the scaling should be performed on the ZPA of the floor response spectra (FRS), using the ratio of the peak ground spectral accelerations at the dominant structural response frequency. Neither of these requirements was complied with in the scaling procedure used in the BVPS-2 IPEEE study. Please provide justification for the scaling procedure used in the IPEEE, and if some commonly used reference was used, please provide any relevant reference materials that may facilitate the staff's IPEEE review.

(c) The BVPS-2 design basis spectrum has a shape comparable to the NUREG/CR-0098 median spectra, which are used as the general seismic criteria for the seismic IPEEE evaluations. Please discuss the results of the fragility calculations if the NUREG/CR-0098 median spectrum shape is used, and discuss the impact, if any, on the BVPS-2 seismic accident sequences.

(d) In Section 3.1.3 of the IPEEE submittal, it is stated that for initial screening the spectral shape of NUREG/CR-0098 anchored to 0.3g was used. However, subsequently, a second screening

was performed using 0.5g threshold criteria. It is unclear whether the second screening was performed consistently, i.e., using the spectral shape of NUREG/CR-0098 anchored to 0.3g. Please provide clarification. In addition, the bulk of the IPEEE fragility data, expressed as a percentage of g, came from generic information. Please describe with what spectral shape these generic fragility data are associated.

(e) Please provide the detailed fragility calculations (including also the natural frequency characteristics with the assumed SSI effects, if any, and floor response spectra used) for the following components. If possible, please use the corrected UHS shape (as discussed above) and the NUREG/CR-0098 median spectrum.

- *Reactor Coolant Pumps (HCLPF = 0.61g)*
- *Cable Trays and supports (HCLPF = 0.65g)*
- *Heating ventilation and air conditioning-related ducting and supports (HCLPF = 0.65g)*
- *Boric acid tanks (HCLPF = 2.45g)*
- *Emergency diesel (HCLPF = 0.28g)*
- *Emergency Response Facility (ERF) diesel generator (HCLPF = 0.26g)*

Response to Request 1.

BVPS-2 IPEEE SPRA used the UHS spectrum as a basis for fragility quantification as endorsed by NUREG-1407 and described in NUREG/CR-5250. The use of other shaped ground spectral input was not discussed in NUREG-1407 for the SPRA, and therefore, it was not used by BVPS-2 in performing the fragility analysis or in ranking the failure sequences and identifying potential plant vulnerabilities. As discussed by the NRC staff introduction to the topic of ground input spectral shape above, BVPS-2 recognized that the UHS shape is somewhat unrealistic. However, the NRC recommended the use of the UHS for performing the SPRA in NUREG-1407 even though the shape is unrealistic when compared to typical design response spectra or spectra generated from real earthquakes. BVPS-2 used a more conservative methodology than recommended by NUREG-1407 in order to have a cost effective SPRA that realistically include the earthquake hazard in the IPEEE. Implicit in the BVPS-2 IPEEE is the conservative nature of the initial screening evaluation. Since the initial screening was performed using the guidance of EPRI report NP-6041, the screening estimates made by the walkdown team were based on NUREG/CR-0098 shaped spectra. There were also other conservatisms implicit in the SPRA that will be discussed in responses to 1(a), 1(b), 1(c) and 1(d) below.

The effect of seismic input spectral shape on the fragility quantification for BVPS-2 components is not known and cannot be determined without a significant analytical and/or research effort. The seismic input shape may in fact play an important role in fragility quantification. However, to use a different, more traditional spectral shape would require use of a different hazard description. A hazard description consistent with a NUREG/CR-0098 response spectra is not available in the literature. Otherwise, the probability of exceedance for spectral accelerations between 2 Hz and 10 Hz (the frequency range that most commonly would cause damage to nuclear structures, equipment and components) would be overstated. This condition would distort the results of the SPRA and the ranking of failure sequences.

The results of the BVPS-2 SPRA are reflective of the conservative seismic design basis for the station.

The revised LLNL curves for BVPS-2 indicate that the original plant design basis SSE has sufficient margin for the earthquake hazard as a reduced-scope plant. Figure 3.11 of the IPEEE submittal is an illustration of the inherent margin of the BVPS-2 design basis SSE. The PGA return period for the Uniform Hazard Spectrum (UHS) shown in Figure 3.11 as described below in response to question 1(a) below is 1.0E-04. NUREG-1407 endorses the use of the EPRI UHS for performing the IPEEE PRA, and states that the "slopes of the seismic hazard" between EPRI and LLNL "are not significantly different over those ground motion levels".

The design basis SSE below 10 Hz. is greater than the UHS spectrum at the 1.0E-4 level using the EPRI data for annual probability of exceedance. One would have to scale the UHS spectrum up to a 50th percentile probability of exceedance using the new LLNL data to a level of 9.352E-05 for the UHS hazard curve to exceed the design basis SSE from 10 Hz and above. The probability of exceedance will go as low as 1.837E-05 and 2.789E-07 for the UHS hazard to be above the SSE design basis at 5 Hz and above, and 2 Hz and above, respectively. It is reasonable to expect that the acceptance criteria for seismic loads at BVPS-2 would insure at least a 0.1 conditional core damage frequency at the design basis earthquake level. Combining the probability of exceedance with conditional core damage frequency the overall risk from seismic loads is less than 1.0E-06. It is also interesting to note that at 2 Hz, BVPS-2 has almost been designed to an earthquake level that for other loading types did not have to be considered in an IPEEE (1.0E-07).

Response to Request 1(a).

The PGA for a return period of 1.0E-04 for the UHS curve used for the BVPS-2 is approximated by logarithmic interpolation as 0.09g. No guidance as to what frequency the ZPA should be anchored to is provided, and hence, based on discussions with industry experts at the time the work was performed, a frequency of 50 Hz was used. Due to use of scaling to establish amplified response spectra for the purposes of estimating structure, equipment, and component fragility levels however, the PGA and what frequency it was anchored at had essentially no impact since the seismic response of the structures, equipment, and components above about 25 Hz generally does not effect the seismic fragility. In addition, in the scaling process, with respect to the design amplified response spectra, the scaled spectra were flattened at the acceleration level corresponding to 33 Hz for all frequencies above 33 Hz. Due to the peak of the UHS for Beaver Valley being defined from 10 to 25 Hz, this resulted in little difference between seismic response levels above 25 Hz and those between 10 to 25 Hz. Ultimately then, the scaled response spectra were set with the 0.151g spectral acceleration defined at 25 Hz effective at all frequencies above 25 Hz rather than the lower defined PGA for the UHS. This is conservative since the SPRA essentially assumed that the spectral accelerations above 25 Hz at the 1.0E-04 return period were at 0.151g rather than 0.09g.

Response to Request 1(b).

Due to the conservative level of the BVPS-2 design basis seismic design criteria as discussed in the BVPS response to the introduction of 1 above, it was determined that generation of new SSI FRS was not cost effective or justified. The scaling method in EPRI NP-6041-SL is described as "one acceptable method". This method is crude in comparison to the method used to scale the FRS for the BVPS-2 SPRA. It is also noted that the majority of the cautions regarding use of the scaling method described in EPRI NP-6041 are in order to insure that the scaled spectra are not overly conservative. However, BVPS-

2 made the decision to accept the conservative nature of the resulting scaled spectra due to the conservatism in the design basis spectra.

Conservatism was introduced by holding constant the building damping in the scaling process of the BVPS-2 design basis FRS. The BVPS-2 FSAR indicates that composite modal damping was applied. This modal damping was limited to 10% of critical (ignoring radiation damping effects) for all structures except the Reactor Containment Building. It was not considered justifiable in the SPRA to increase the soil/structure damping without performing a new SSI analysis, so the conservative damping ratio was left the same in the scaling process. Results from the BVPS-1 soil-structure interaction analysis performed in 1979 indicate that higher damping could be justified. This analysis was near state-of-the-art by today's standards. However, the methodology used did introduce some conservatism in the treatment of embedment and damping. Even with this conservatism the overall damping from the BVPS-1 SSI was higher than for BVPS-2. The BVPS-2 design basis spectra that were scaled were also artificially broadened introducing another conservatism.

The nonlinearities in soil properties is effected by the amplitude of the input motion, particularly in the frequency range of about 1.5 Hz to 5 Hz for soft soils. While the ground response spectra used for the design basis analysis corresponds to a much more energetic earthquake in this range than the median UHS curve (UHS curve deamplifies the associated PGA at 2.5 Hz to about one-half) for equal ZPGA values, pushing the UHS spectrum to an equivalent of about 0.45g to 0.6g (as would be typical in performing full SSI analysis to generate amplified response spectra for an SPRA study) results in spectral accelerations for the UHS spectrum equal to or greater than the ground spectrum associated with the design basis analysis. Due to the shape of the UHS spectrum, SSI response results using the UHS spectrum would be expected to be about the same as the 1979 SSI evaluation at about 2.5 Hz and below, and would likely be reduced at response frequencies above this value.

Based on these considerations, and the conservatism included in the design basis spectra, it was determined that a new full SSI analysis was not warranted. There are also inherent difficulties associated with use of the UHS spectrum shape (prescribed by the NRC for use in an SPRA for the IPEEE program) in generating compatible time-history functions. The scaled spectra were considered conservative, and that no <u>increase</u> in damping due to the SSI effects could be justified without performing a new analysis.

As described below, the scaled amplified response spectra used to estimate fragilities were scaled up relative to ZPA. The spectra are scaled down due to the effect of the change in equipment damping (1% for the design amplified response spectra compared to 5% for the scaled response spectra) and to the shape of the UHS spectrum which was prescribed by the NRC for use in IPEEE reviews by SPRA.

The FRS were scaled using Stevenson & Associates proprietary program TFRS. The TFRS program uses the existing floor response curves and the initial ground response spectrum to generate transfer functions across the frequency range of interest for each floor response spectrum. The transfer functions reflect the response of the structure and associated structural damping and are relative to the equipment damping of the floor response spectrum. Using these transfer functions and the UHS, new FRS are calculated with the specified changes to structural and/or equipment damping. A more detailed description of program TFRS is included as Attachment A to this response. In the BVPS-2 SPRA, scaled spectra were developed by:

- Changing the ZPGA from 0.125g to 0.151g
- Changing the equipment damping ratio from 1% to 5%
- Changing the DBE response spectrum shape to the defined UHS shape

Response to Request 1(c).

As discussed in the BVPS response to the introduction of this question and the response to 1(a) above, it is not anticipated that use the NUREG/CR-0098 median shaped would significantly change the results of the BVPS-2 SPRA. This statement assumes that use of the NUREG/CR-0098 would be coupled with the use of appropriately modified hazard curves, that would have the same probability of exceedance in the 2.5 Hz to 5 Hz range discussed in response to the introduction of this issue. It is not anticipated that the appropriate use of this ground spectrum shape would impact either the fragility calculations or BVPS-2 seismic accident sequences. However, if this input is inappropriately used by anchoring the NUREG/CR-0098 spectrum to the UHS spectral acceleration at 33 Hz and using the UHS hazard curves, the results could change significantly. An SPRA performed in this manner would result in the probability of exceedance for spectral accelerations between 2 Hz and 10 Hz (the frequency range that most commonly would cause damage to nuclear structures, equipment and components) being overstated. This condition would distort the results of the SPRA and the ranking of failure sequences.

Although it is speculated that the results would not change significantly, the effect of seismic input spectral shape on the fragility quantification for BVPS-2 components is not known with certainty and cannot be determined without a significant analytical and/or research effort. This additional effort is not justified for BVPS-2 due to the inherent conservatism of the original seismic design basis, the conservatism of the BVPS-2 SPRA methodology discussed above and the BVPS-2 SPRA results.

Response to Request 1(d).

As described in Section 3.1.3 of the IPEEE submittal, the initial walkdown estimated HCLPF values based on the NUREG/CR-0098 spectral shape. When generic fragilities were calculated, UHS FRS were used. When generic data were used for a specific equipment item or component, the capacity was based on the generic data and the UHS FRS were used as the demand to develop the overall fragility. When generic data was used for an assigned fragility for a component class like HVAC ducting and supports, and NSSS piping, the NUREG/CR-0098 spectral shape was implicitly used since a similar spectral shape was used to develop the generic data. The resulting HCLPF values, which were compared against the 0.5g second screening criteria, are all relative to the PGA of these defined hazard spectra.

Response to Request 1(e).

As discussed in Section 3.1.4.1 of the submittal, two approaches were used to estimate the fragility parameters for risk-related plant components and structures that could not be screened out. The first action was to review the seismic walkdown notes and photographs taken of BVPS-2 components and to compare them with like-information from the seismic analysis performed in the BVPS-1 IPEEE for similar components. To the extent possible, conservative values were assigned to the BVPS-2 components using the BVPS-1 information. Using this approach, most BVPS-2 equipment or components did not require the performance of specific detailed fragility calculations. In general, equipment and components in BVPS-2 were either identical or similar to BVPS-1 equipment and components. Anchorage for BVPS-2 equipment was either identical or stronger than BPVS-1 equipment. This was due to the initial seismic design input for BVPS-2 being of greater magnitude than the initial seismic design basis input for BVPS-1. The fragility was therefore conservatively based on the BVPS-1 values for equipment and components.

The following discussion describe the HCLPF quantification included in the IPEEE submittal for the items requested:

Reactor Coolant Pumps: The HCLPF value for the reactor coolant pumps was estimated to be equal to 0.61g. The BVPS-2 Reactor Coolant Pumps are large (6,000 horsepower) vertical pumps that are supported on the same support system with the steam generators. The BVPS-2 Reactor Coolant Pumps were judged to have a seismic fragility that was equal to or exceeded the fragility of the BVPS-1 Reactor Coolant Pumps. Therefore, the BVPS-2 Reactor Coolant Pumps were not selected for a detailed calculation. The calculation for the BVPS-1 Reactor Coolant Pumps (included as Attachment B) was used as the basis for their estimated HCLPF.

Cable Trays and Supports: The HCLPF for these components was assigned based on generic data to be 0.65g. The Seismic Review Team based this assignment on a walk-by of a portion of the cable tray and support systems at BVPS-2. The systems were found to be well supported and not susceptible to earthquake damage. Cable trays and supports are discussed in NUREG/CR-4334 "An Approach to the Quantification of Seismic Margins in Nuclear Power Plants". The report states in Section C.17 that "cable trays have not been identified as important contributors to seismic risk in the PRAs because of their large seismic capacities". The HCLPF assigned for BVPS-2 is an average of the generic values used for the SPRA of other nuclear stations as reported in Table C-26 of NUREG/CR-4334.

Heating Ventilation and Air Conditioning Related Ducting and Supports: The HCLPF for these components was assigned based on generic data to be 0.65g. The Seismic Review Team based this assignment on a walk-by of a portion of the heating ventilation and air conditioning ducting and support systems at BVPS-2. The systems were found to be well supported and not susceptible to earthquake damage. Heating ventilation and air conditioning ducting and supports are discussed in NUREG/CR-4334. The report states in Section C.16 that "HVAC system components (i.e., fans, cooling units, and ducts) have not been identified as important contributors to seismic risk in the PRAs conducted to date." These systems are in general controlled by the capacity of the fans and cooling units. The fan and cooling unit portion of the HVAC system components are modeled in the BVPS-2 SPRA when they control the system capacity. The HCLPF assigned for BVPS-2 is an average of the generic values used for the SPRA of other nuclear stations as reported for cable tray supports in Table C-26 of NUREG/CR-4334. The HVAC and Cable Tray supports at BVPS-2 are of similar construction. The capacities of the HVAC supports were judged by the Seismic Review Team to be about the same as the Cable Tray supports discussed above.

Boric Acid Tanks: The HCLPF calculation for the Boric Acid Tanks was performed using S&A proprietary program TANKV. TANKV calculates the HCLPF for the large flat bottom tanks using the methodology developed by Kennedy as originally presented in EPRI 6041-SL "A Methodology for Assessment of Nuclear Power Plant Seismic Margin" and later updated in TR-103959

"Methodology for Developing Seismic Fragilities". A description of program TANKV is included as an Attachment C to this response. The HCLPF calculated using this methodology is 2.45g due to the rugged anchorage for the tanks. The HCLPF calculations for BVPS-2 flat bottom tanks are included as Attachment D to this response. The calculation for the BVPS-2 Boric Acid Tanks are included in pages 21 to 29 of the attachment.

Emergency Diesel: The HCLPF for the Emergency Diesels was controlled by the HCLPF for the Emergency Diesel Generator Building. The calculated HCLPF for the Emergency Diesel Generator Building was estimated to be equal to 0.28g. The fragility calculations for the BVPS-2 buildings are included as Attachment E to this response. The calculation for the Emergency Diesel Generator Building is included in pages 9 to 12 of the attachment. The HCLPF for the Emergency Diesel Generator itself is much higher than for the building. The HCLPF for the BVPS-1 Emergency Diesel Generators was calculated to be 3.6g. This calculation is included as Attachment F to this response. Specific detailed fragility calculations for the BVPS-2 Emergency Diesel Generators were not performed based on the BVPS-1 results and the reasons discussed in the introduction to this response.

Emergency Response Facility (ERF) Diesel Generator: The HCLPF for the Emergency Response Facility (ERF) Diesel Generator was controlled by the HCLPF for the ERF Diesel Generator Building. The calculated HCLPF for the building was estimated based on the calculation for the BVPS-1 Emergency Diesel Generator Building, which was of similar construction. The BVPS-1 Emergency Diesel Generator Building fragility calculation is included as Attachment G to this response. The estimated HCLPF for the ERF Diesel Generator Building was 0.26g. Specific detailed fragility calculations for the ERF Diesel Generator Building were not performed. The HCLPF for the ERF Diesel Generator itself is much higher than for the building. The HCLPF for the BVPS-1 Emergency Diesel Generators was calculated to be 3.6g. This calculation is included as Attachment F to this response. Specific detailed fragility calculations for the ERF Diesel Generator were not performed based on the BVPS-1 Emergency Diesel Generator results and the reasons discussed in the introduction to this response.

Request 2.

The top 100 sequences are presented in the IPEEE submittal; however it is difficult to understand their meaning, as split fraction acronyms (a unique PRA [Probabilistic Risk Assessment] term) are used which are not explained. A discussion of a few top sequences would be helpful in understanding the seismic vulnerability results obtained in the IPEEE. Please provide a description of the top 5 sequences, including the acceleration levels used for the sequences, the seismically induced failures, and non-seismic and human failures which occur during the sequence, as well as the required operator actions and their timing. If fragility estimates of equipment and structures are revised as a result of Request for Additional Information (RAI) No. 1 above, and this results in a different set of top 5 sequences, please also provide the description of the new top five sequences.

Response to Request 2.

Detailed descriptions of the seismic top events (defined by the "Z" in the first letter of the split fraction) are presented in Section 3.1.5.1 of the BVPS-2 IPEEE submittal, while detailed descriptions of the non-seismic top events are presented in Sections 3.1.3 and 3.1.5 of the BVPS-2 IPE submittal. The split fraction number following the seismic top event designator relates to the seismic initiating event acceleration level. For example, ZC3 refers to the seismic failure of the offsite grid during earthquakes in the SEIS3 (0.35g to 0.5g) range. The split fraction letter "F" following the non-seismic top events designates that the top event is a guaranteed failure due to prior events. Detailed descriptions of the top 5 sequences presented in Table 3-12 of the IPEEE submittal are provided in Attachment H of this response.

Table 3.3.3-5 of the BVPS-2 IPE submittal gives a summary description of the human actions and their timing. However, as discussed in Section 3.1.5.2 of the BVPS-2 IPEEE submittal, it was assumed that all operator actions would fail above the 0.5g PGA level, and that human error rates below this level would not be affected. It also goes on to say that this assumption was conservatively accomplished by setting all top events that included operator actions to a guaranteed failure for earthquakes above the 0.5g PGA level. The resultant of this assumption is that the plant fragility (conditional core damage frequency) is essentially 1.0 for all seismic initiating events greater than 0.5g. It should be noted that no credit for electric power recovery was given for seismic initiating events, at any level.

The first independent (non-seismic) system failure does not occur until Sequence 6, in Table 3-12 of the IPEEE submittal, in which split fraction AF3 fails. This independent failure of the steam/turbine driven auxiliary feedwater (AFW) pump results in a failure of the AFW system, given that both motor driven AFW pumps and the automatic makeup to the primary plant demineralized water storage tank are unavailable, due to the seismic failure of the offsite grid and emergency AC power. However, since a non-recoverable seismic induced station blackout has already occurred, this independent failure is irrelevant.

The fragility estimates did not change as a result of the response to seismic RAI No.1, so a brief description of only the top 5 sequences presented in Table 3-12, of the BVPS-2 IPEEE submittal and how they result in core damage is provided below:

Sequence 1. An earthquake in the 0.5g to 1.0g range occurs, resulting in the seismic failure of the offsite grid, the normal AC & DC power supplies, and the emergency AC power supplies. Consequently, this results in a non-recoverable station blackout due to the seismic failures of emergency AC power and the normal AC & DC power supplies, and ultimately results in core damage via an RCP seal LOCA without makeup. In addition, the ERF diesel generator power supply, which provides power to the station and containment instrument air systems, also fails seismically. Likewise, due to the earthquake ground acceleration values exceeding the 0.5g PGA level, it was assumed that all top events with operator actions would fail.

Sequence 2. An earthquake in the 0.5g to 1.0g range occurs, resulting in the seismic failure of the offsite grid, the normal AC & DC power supplies, and the ERF diesel generator power supply. However, due to the earthquake ground acceleration values exceeding the 0.5g PGA level, it was assumed that all top events with operator actions would fail. This accordingly, results in the failure of both trains of Service Water/Standby Service Water (the ultimate heat sink). The emergency diesel generators successfully start due to the failure of the offsite grid and normal power supplies; however, without service water to cool the diesels, they eventually fail to run. Once again, this results in a non-recoverable station blackout and ultimately results in core damage by way of an RCP seal LOCA without makeup.

Sequence 3. An earthquake in the 0.35g to 0.5g range occurs, resulting in the seismic failure of the offsite grid, the emergency AC power supplies, and the ERF diesel generator power supply. Therefore, this sequence also results in a non-recoverable station blackout due to the seismic failures of the offsite grid and emergency AC power supplies. This too, ultimately results in core damage via an RCP seal LOCA without makeup.

Sequence 4. This sequence is similar to Sequence 1 above, except that it occurs at lower earthquake ground acceleration values (i.e., in the 0.35g to 0.5g range) so top events with operator actions are not guaranteed failures.

Sequence 5. This sequence is similar to Sequence 3 above, except that it occurs at higher earthquake ground acceleration values (i.e., in the 0.5g to 1.0g range). Additionally, due to the earthquake ground acceleration values exceeding the 0.5g PGA level, it was assumed that all top events with operator actions would fail.

Request 3.

The instrument air system could affect containment performance because it may be needed for motive power for isolation valves and for the functioning of inflatable containment hatches. There is no discussion in the submittal as to how failures of the instrument air system affects containment performance issues. Please provide such a discussion.

Response to Request 3.

One of the functions of the station instrument air system and containment instrument air system is to supply compressed air to safety related air operated valves (AOVs), including containment isolation AOVs. The outboard containment isolation AOVs are controlled by station instrument air, while the inboard containment isolation AOVs are controlled by the containment instrument air system. These compressed air systems however, are non-safety related because the AOVs are designed to fail in a safe position (e.g., containment isolation valves fail closed upon loss of compressed air). Additionally, the design of the BVPS-2 personnel air lock and equipment hatches utilize double O-ring gaskets as its sealing mechanism, which do not require any compressed air supply. Therefore, there is no impact on the containment performance resulting from the failures of station instrument air and containment instrument air systems.

ATTACHMENT A

Description of Stevenson & Associates Program TFRS

The TRFS program modifies existing floor response spectra for different base ground response spectra, different equipment damping, and different structural damping. There are three options (for three different methods) in the program for accomplishing this. Choice of which option is generally a function of the characteristics of the existing floor response spectrum, plus the amount of known information relative to the dynamic characteristics of the structure.

The three options in TFRS are:

1) RS-PSD Transformation
2) Multiple Spectral Amplification Factor Amplification (direct method)
3) Modal Time History Transformation

The second method was selected and used for to perform the modification or scaling of the Beaver Valley Unit 2 floor response spectra for use in the IPEEE PRA study.

For this method, input consists of the original ground response spectrum and its associated damping used to generate the existing floor response spectra, the existing floor response spectra and their associated damping, the original damping value/values (composite modal damping can be used) for the structures, the new ground response spectrum if any, the original zero period ground acceleration (ZPGA), the new ZPGA, and what equipment damping values are desired.

The transformation is performed by first calculating amplification factors from the existing floor response spectra relative to the original ground response spectra. Any change to ZPGA is accounted for in this step also:

AMF = FRSOLD/GRSOLD * (ZPGANEW/ZPGAOLD)

These amplification factors are computed at several frequencies across the entire frequency band defined by the minimum frequency and maximum frequency used to describe the input floor response spectrum. Frequencies are selected based on a given frequency interval, with peaks at structural modes automatically included. If the input spectra are broadened, the "corner" frequencies of each broadened peak are also automatically included. Interpolation of intermediate spectral values between input frequency values are obtained by log-log interpolation.

New floor response spectra are then calculated using the amplification factors previously determined with the new ground response spectra, modified by factors for changes to structural and/or equipment damping.

ATTACHMENT B

Fragility Calculation for the BVPS-1 Reactor Coolant Pumps