December 7, 2000

Mr. Mark Reddemann
Site Vice President
Kewaunee and Point Beach Nuclear Power Plants
Nuclear Management Company, LLC
6610 Nuclear Road
Two Rivers, WI 54241

SUBJECT: SITE-SPECIFIC WORKSHEETS FOR USE IN THE NUCLEAR REGULATORY COMMISSION'S SIGNIFICANCE DETERMINATION PROCESS (TAC NO. MA6544)

Dear Mr. Reddemann:

Enclosed please find the Risk-Informed Inspection Notebook which incorporates the updated Significance Determination Process (SDP) Phase 2 Worksheets that inspectors will be using to characterize and risk-inform inspection findings. This document is one of the key implementation tools of the reactor safety SDP in the reactor oversight process and is also publically available through the Nuclear Regulatory Commission (NRC) ADAMS system.

The 1999 Pilot Plant review effort clearly indicated that significant site-specific design and risk information was not captured in the Phase 2 worksheets forwarded to you last spring. Subsequently, a site visit was conducted by the NRC to verify and update plant equipment configuration data and to collect site-specific risk information from your staff. The enclosed document reflects the results of this visit.

The enclosed Phase 2 Worksheets have incorporated much of the information we obtained during our site visits. The staff encourages further licensee comments where it is identified that the Worksheets give inaccurately low significance determinations. Any comments should be forwarded to the Chief, Probabilistic Safety Assessment Branch, Nuclear Regulatory Regulation (NRR). We will continue to assess SDP accuracy and update the document based on continuing experience.

While the enclosed Phase 2 Worksheets have been verified by our staff to include the site specific data, we will continue to assess its accuracy throughout implementation and update the document based on comments by our inspectors and your staff.

We will coordinate our efforts through your licensing or risk organizations as appropriate.

If you have any questions regarding this matter, please contact me at (301) 415-1446.

Sincerely,

/RA/

John G. Lamb, Project Manager, Section 1
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-305

Enclosure: As Stated

cc w/encls: See next page

If you have any questions regarding this matter, please contact me at (301) 415-1446.

Sincerely,

/RA/

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RISK-INFORMED INSPECTION NOTEBOOK FOR

KEWAUNEE NUCLEAR POWER PLANT

PWR, WESTINGHOUSE, TWO-LOOP PLANT WITH LARGE DRY CONTAINMENT

Prepared by

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NOTICE

This notebook was developed for the NRC's inspection teams to support risk-informed inspections. The activities involved in these inspections are discussed in "Reactor Oversight Process Improvement," SECY-99-007A, March 1999. The user of this notebook is assumed to be an inspector with an extensive understanding of plant-specific design features and operation. Therefore, the notebook is not a stand-alone document, and may not be suitable for use by non-specialists. This notebook will be periodically updated with new or replacement pages incorporating additional information on this plant. All recommendations for improvement of this document should be forwarded to the Chief, Probabilistic Safety Assessment Branch, NRR, with a copy to the Chief, Inspection Program Branch, NRR.

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ABSTRACT

This notebook contains summary information to support the Significance Determination Process (SDP) in risk-informed inspections for the Kewaunee Nuclear Power Plant.

The information includes the following: Categories of Initiating Events Table, Initiators and System Dependency Table, SDP Worksheets, and SDP Event Trees. This information is used by the NRC's inspectors to identify the significance of their findings, i.e., in screening risk-significant findings, consistent with Phase 2 screening in SECY-99-007A. The Categories of Initiating Event Table is used to determine the likelihood rating for the applicable initiating events. The SDP worksheets are used to assess the remaining mitigation capability rating for the applicable initiating event likelihood ratings in identifying the significance of the inspector's findings. The Initiators and System Dependency Table and the SDP Event Trees (the simplified event trees developed in preparing the SDP worksheets) provide additional information supporting the use of SDP worksheets.

The information contained herein is based on the licensee's Individual Plant Examination (IPE) submittal, the updated Probabilistic Risk Assessment (PRA), and system information obtained from the licensee during site visits as part of the review of earlier versions of this notebook. Approaches used to maintain consistency within the SDP, specifically within similar plant types, resulted in sacrificing some plant-specific modeling approaches and details. Such generic considerations, along with changes made in response to plant-specific comments, are summarized.

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1. INFORMATION SUPPORTING SIGNIFICANCE DETERMINATION PROCESS (SDP)

SECY-99-007A (NRC, March 1999) describes the process for making a Phase 2 evaluation of the inspection findings. The first step in this is to identify the pertinent core damage scenarios that require further evaluation consistent with the specifics of the inspection findings. To aid in this process, this notebook provides the following information:

1. Estimated Likelihood Rating for Initiating Event Categories
2. Initiators and System Dependency Table
3. Significance Determination Process (SDP) Worksheets
4. SDP Event Trees.

Table 1, Categories of Initiating Events, is used to estimate the likelihood rating for different initiating events for a given degraded condition and the associated exposure time at the plant. This Table follows the format of Table 1 in SECY-99-007A. Initiating events are grouped in frequency bins that are one order of magnitude apart. The Table includes the initiating events that should be considered for the plant and for which SDP worksheets are provided. The following initiating events are categorized by industry-average frequency: transients (Reactor Trip) (TRANS); transients without power conversion system (TPCS); large, medium, and small loss of coolant accidents (LLOCA, MLOCA, and SLOCA); inadvertent or stuck open relief valve (IORV or SORV); main steam line break (MSLB), anticipated transients without scram (ATWS), and interfacing system LOCA (ISLOCA). The frequency of the remaining initiating events vary significantly from plant to plant, and accordingly, they are categorized by plant-specific frequency obtained from the licensee. They include loss of offsite power (LOOP) and special initiators caused by loss of support systems.

The Initiators and System Dependency Table shows the major dependencies between frontline- and support-systems, and identifies their involvement in different types of initiators. This table identifies the most risk-significant systems; it is not an exhaustive nor comprehensive compilation of the dependency matrix, as known in Probabilistic Risk Assessments (PRAs). For pressurized water reactors (PWRs), the support systems/success criteria for Reactor Coolant Pump (RCP) seals are explicitly denoted to assure that the inspection findings on them are properly accounted for. This Table is used to identify the SDP worksheets to be evaluated, corresponding to the inspection's findings on systems and components.

To evaluate the impact of the inspection's findings on the core-damage scenarios, SDP worksheets are provided. There are two sets of SDP worksheets; one for those initiators that can be mitigated by redundant trains of safety systems, and the other for those initiators that cannot be mitigated; however, their occurrence is prevented by several levels of redundant barriers.

The first set of SDP worksheets contain two parts. The first identifies the functions, the systems, or combinations thereof that have mitigating functions, the number of trains in each system, and the number of trains required (success criteria) for the initiator. It also characterizes the mitigation capability in terms of the available hardware (e.g., 1 train, 1 multi-train system) and the operator action involved. The second part of the SDP worksheet contains the core-damage accident sequences associated with each initiator; these sequences are based on SDP event trees. In the parenthesis next to each sequence, the corresponding event-tree branch number(s) representing the sequence is given. Multiple branch numbers indicate that the different accident sequences identified by the event tree have been merged into one through Boolean reduction. The SDP worksheets are developed for each of the initiating event categories, including the "Special Initiators", the exception being those which directly lead to a core damage (the inspections of these initiators are assessed differently; see SECY-99-007A). The special initiators are those that are caused by complete or partial loss of support systems. A special initiator typically leads to a reactor scram and degrades some frontline or support systems (e.g., Loss of CCW in PWRs).

In considering the special initiators, we defined a set of criteria for including them to maintain some consistency across the plants. These conditions are as follows:

1. The special initiator should degrade at least one of the mitigating safety functions thereby changing its mitigation capability in the worksheet. For example, when a safety function with two redundant trains, classified as a multi-train system, degrades to a one-train system, it is classified as 1 Train, due to the loss of one of the trains as a result of the special initiator.

2. The special initiators which degrade the mitigation capability of the systems/functions associated with the initiator from comparable transient sequences by two and higher orders of magnitude must be considered.

From the above considerations, the following classes of initiators are considered in this notebook:

1. Transients with power conversion system (PCS) available, called Transients (Reactor trip) (TRANS),
2. Transients without PCS available, called Transients w/o PCS (TPCS),
3. Small Loss of Coolant Accident (SLOCA),
4. Stuck-open Power Operated Relief Valve (SORV),
5. Medium LOCA (MLOCA),
6. Large LOCA (LLOCA),
7. Steam Generator Tube Rupture (SGTR),
8. Anticipated Transients Without Scram (ATWS), and
9. Main Steam Line Break (MSLB).

Examples of special initiators included in the notebook are as follows:

1. Loss of Offsite Power (LOOP),
2. LOOP with failure of 1 Emergency AC bus or associated EDG (LEAC),
3. Loss of 1 DC Bus (LDC),
4. Loss of component cooling water (LCCW),
5. Loss of instrument air (LIA),
6. Loss of service water (LSW).

The worksheet for the LOOP includes LOOP with emergency AC power (EAC) available and LOOP without EAC, i.e., Station Blackout (SBO). LOOP with partial availability of EAC, i.e., LOOP with loss of a bus of EAC, is covered in a separate worksheet to avoid making the LOOP worksheet too large. In some plants, LOOP with failure of 1 EAC bus is a large contributor to the plant's core damage frequency (CDF).

The second set of SDP worksheets addresses those initiators that cannot be mitigated, i.e., can directly lead to core-damage. It currently includes the Interfacing System LOCA (ISLOCA) initiator. ISLOCAs are those initiators that could result in a loss of RCS inventory outside the containment, sometimes referred to as a "V" sequence. In PWRs, this event effectively bypasses the capability to utilize the containment sump recirculation once the RWST has emptied. Also, through bypassing the containment, the radiological consequences may be significant. In PWRs, this typically includes loss of RCS inventory through high- and low-pressure interfaces, such as RHR connections, RCP thermal barrier heat-exchanger, high-pressure injection piping if the design pressure (pump head) is much lower than RCS pressure, and, potentially, through excess letdown heat exchanger. RCS inventory loss through ISLOCA could vary significantly depending on the size of the leak path; some may be recoverable with minimal impact. The SDP worksheet for ISLOCA, therefore, identifies the major consequential leak paths, and the barriers that should fail, allowing the initiator to occur.

Following the SDP worksheets, the SDP event trees corresponding to each of the worksheets are presented. The SDP event trees are simplified event trees developed to define the accident sequences identified in the SDP worksheets. For special initiators whose event tree closely corresponds to another event tree (typically, the Transient (Reactor trip) or Transients w/o PCS event tree) with one or more functions eliminated or degraded, a separate event tree may not be drawn.

The following items were considered in establishing the SDP event trees and the core-damage sequences in the SDP worksheets:

1. Event trees and sequences were developed such that the worksheet contains all the major accident sequences identified by the plant-specific IPEs/PRAs. The special initiators modeled for a plant is based on a review of the special initiators included in the plant IPE/PRA and the information provided by the licensee.

2. The event trees and sequences for each plant take into account the IPE/PRA models and event trees for all similar plants. For modeling the response to an initiating event, any major deviations in one plant from similar plants may be noted at the end of the worksheet.

3. The event trees and the sequences were designed to capture core-damage scenarios, without including containment-failure probabilities and consequences. Therefore, branches of event trees that are developed only for the purpose of a Level II PRA analysis are not considered. The resulting sequences are merged, using Boolean logic.

4. The simplified event trees focus on classes of initiators, as defined above. In so doing, many separate event trees in the IPEs/PRAs often are represented by a single tree. For example, some IPEs/PRAs define four classes of LOCAs rather than the three classes considered here. The sizes of LOCAs for which high-pressure injection is not required are sometimes divided into two classes, the only difference between them being the need for reactor scram in the smaller break size. There may be some consolidation of transient event trees besides defining the special initiators following the criteria defined above.

5. Major actions by the operator during accident scenarios are credited using four categories of Human Error Probabilities (HEPs). They are termed operator action =1 (representing an error probability of 5E-2 to 0.5), operator action=2 (error probability of 5E-3 to 5E-2), operator action=3 (error probability of 5E-4 to 5E-3), and operator action=4 (error probability of 5E-5 to 5E-4). An human action is assigned to a category bin, based on a generic grouping of similar actions among a class of plants. This approach resulted in designation of some actions to a higher bin, even though the IPE/PRA HEP value may have been indicative of a lower category. In such cases, it is noted at the end of the worksheet. On the other hand, if the IPE/PRA HEP value suggests a higher category than that generically assumed, the HEP is assigned to a bin consistent with the IPE/PRA value in recognition of potential plant-specific design; a note is also given in these situations. Operator's actions belonging to category 4, i.e., operator action=4, may only be noted at the bottom of worksheet because, in those cases, equipment failures may have the dominating influence in determining the significance of the findings.

The four sections that follow include Categories for Initiating Events Table, Initiators and Dependency Table, SDP worksheets, and the SDP event trees for the Kewaunee Nuclear Power Plant.

1.1 INITIATING EVENTS LIKELIHOOD RATINGS

Table 1 presents the applicable initiating events for this plant and their estimated likelihood ratings corresponding to the exposure time for degraded conditions. The initiating events are grouped into rows based on their frequency. As mentioned earlier, loss of offsite power (LOOP) and special initiators are assigned to rows using the plant-specific frequency obtained from individual licensees. For other initiating events, industry-average values are used.

Table 1 Categories of Initiating Events for Kewaunee Nuclear Power Plant

Row	Approximate Frequency	Example Event Type	Estimated Likelihood Rating		
I	> 1 per 1-10 yr	Reactor Trip (TRANS), Loss of Power Conversion System (TPCS)	A	B	C
II	1 per 10-10^2 yr	Loss of Offsite Power (LOOP), Loss of one 125V DC Bus (LDC)	B	C	D
III	1 per 10^2 - 10^3 yr	SGTR, Stuck open PORV/SRV (SORV), Small LOCA including RCP seal failures (SLOCA), MSLB/FLB (outside containment), Loss of Instrument Air (LOIA), Loss of CCW (LCCW),	C	D	E
IV	1 per 10^3 - 10^4 yr	Medium LOCA (MLOCA), LOOP with loss of one division of emergency AC (LEAC), Loss of Service Water (LSSW)	D	E	F
V	1 per 10^4 - 10^5 yr	Large LOCA (LLOCA)	E	F	G
VI	less than 1 per 10^5 yr	ATWS-PWR (mechanical only), ISLOCA	F	G	H
			> 30 days	**3-30 days**	**< 3 days**
			Exposure Time for Degraded Condition		

1.2 INITIATORS AND SYSTEM DEPENDENCY

Table 2 lists the systems included in the SDP worksheets, the major components in the systems, and the support system dependencies. The systems' involvements in different initiating events are noted in the last column.

Table 2 Initiators and System Dependency for Kewaunee Nuclear Power Plant

Affected Systems	Major Components	Support Systems	Initiating Event
Accumulators	2 accumulators	None	LLOCA, MLOCA, SLOCA, SORV
AC Power System	AC Power Distribution and AC Instrument Power	125V DC, RPS, HVAC	All
AFW	Two MDPs	4160 V-AC, 125 V-DC, SW[1], RPS, HVAC, 480 V AC	All except LLOCA
	One TDP	125V DC, SW[1], RPS, Main Steam	
CCW	Two pumps and two Heat Exchangers	480 V-AC, 125V DC, RPS, SW, HVAC	All
Condensate / MFW	Two Condensate pumps Two MFW pumps FW Isol. Valves (1/SG) FW Reg. valves (1/SG) FW Bypass Valves (1/SG)	4.16 kV AC, 125V DC, SW, IA[2], 120V AC, 480V AC	TRANS, SLOCA, SORV, MLOCA, LCCW, LDC, LOIA, MSLB, SGTR
Chemical and Volume Control System (CVCS)-Charging Pumps, Boric Acid Transfer Pumps	Three Charging pumps[3],	480 V-AC,120V AC, IA[4]	LCCW, LOSW, ATWS
	Two Boric Acid Transfer Pumps	480 V-AC	ATWS
HPSI	Two SI pumps	4160 V-AC, 480 V-AC, 125 V-DC, SW, CCW, HVAC, RPS	TRANS, TPCS, LDC, LEAC, SLOCA, SORV, MLOCA, LOOP, SGTR, MSLB
DC Power	Buses, battery chargers and batteries	480 V-AC, HVAC	All

Table 2 (Continued)

Affected Systems	Major Components	Support Systems	Initiating Event
EDG	Two EDGs	125V DC, SW, RPS, HVAC, Fuel Oil	LOOP, LEAC
RPS		120 V-AC, 125V DC, HVAC	SLOCA, SORV, MLOCA, LLOCA, ATWS
Instrument Air (IA)	Five Air Compressors	480 V-AC, 120V AC, SW, RPS	TRANS, TPCS, LOSW, LCCW, LDC, LOIA, LEAC, SLOCA, SORV, LOOP, SGTR, MSLB, ATWS
Main Steam	Five Code safety valves for each SG and two ARVs, one per SG	120V AC, IA, N_2 Accumulators (for SG PORVs)	All except LLOCA
Pressurizer Pressure Relief	Two Safety valves and two PORVs with associated block valves	125V DC, IA accumulators (PORVs), 480V AC (block valves)	TRANS, TPCS, LDC, LEAC, SLOCA, SORV, LOOP, SGTR, MSLB, ATWS
RCS	RCP Seals	1 / 3 Charging pumps[5] to seal injection or 1 / 2 CCW pumps and 1/ 2 CCW HXs to thermal barrier heat exchanger	LOOP
RHR/LHSI	Two RHR/LPSI pumps and heat exchangers	4.16 kV AC, 480 V-AC, 125 V-DC, RPS, CCW[6], SW[7], HVAC	All except LOSW, LCCW, LOIA, ATWS
SW	Four pumps	4160 V-AC, 480 V-AC, 120 V-AC, 125 V-DC, IA, RPS	All

Notes:

1. AFW pumps are cooled by the CST water being pumped. SW is the alternate coolant when CST is depleted. CST is the initial (non-safety) source to SGs. SW is the safety grade source to SGs after CST is depleted.

Table 2 (Continued)

2. Air is used for seal water reg. valves and pump recirculation valves, as well as FW regulating and bypass valves.
3. 2/3 Charging pumps are running with one in auto.
4. IA is required by charging pumps A and B. Charging pump C has a DC drive unit.
5. 1/ 2 Charging pumps for a LOOP initiator.
6. CCW is supplied to the RHR pumps for cooling. During low pressure injection, the coolant flow from RWST is considered sufficient to keep the RHR pump cool.
7. SW is supplied to the RHR pump pit fan coolers to provide room cooling. During low pressure injection, the coolant flow from the RWST is considered to be sufficient to preclude the need for room cooling.
8. The plant internal event CDF is 3.61E-5/yr.

1.3 SDP WORKSHEETS

This section presents the SDP worksheets to be used in the Phase 2 evaluation of the inspection findings for the Kewaunee Nuclear Plant. The SDP worksheets are presented for the following initiating event categories:

1. Transients (Reactor Trip) (TRANS)
2. Transients w/o PCS (TPCS)
3. Loss of Service Water (LOSW)
4. Loss of Component Cooling Water (LCCW)
5. Loss of One 125V DC (LDC)
6. Loss of Instrument Air (LOIA)
7. Small LOCA (SLOCA)
8. Stuck-open PORV (SORV)
9. Medium LOCA (MLOCA)
10. Large LOCA (LLOCA)
11. Loss of Offsite Power (LOOP)
12. LOOP with Loss of 1 EAC Bus (LEAC)
13. Steam Generator Tube Rupture (SGTR)
14. Main Steam Line Break (MSLB)
15. Anticipated Transients Without Scram (ATWS)
16. Interfacing Systems LOCA (ISLOCA).

Table 3.1 SDP Worksheet for Kewaunee Nuclear Power Plant — Transients (Reactor trip) (TRANS)

Estimated Frequency (Table 1 Row) __________ Exposure Time __________ Table 1 Result (circle): A B C D E F G H

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Power Conversion System (PCS)	1/2 Main Feedwater trains with 1/2 condensate trains (operator action = 3)
Secondary Heat Removal (AFW)	1 / 2 MDAFW trains (1 multi-train system) or 1/1 TDAFW train (1 ASD train)
Early Inventory, High Pressure Injection (EIHP)	1/2 HPSI pumps (1 multi-train system)
Primary Heat Removal, Feed/Bleed (FB)	1/2 PORVs open for Feed/Bleed (operator action = 2) [(1)]
High Pressure Recirculation (HPR)	1/2 HPSI pumps with 1/2 RHR pumps with operator action for switchover (operator action = 3)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 TRANS - AFW - PCS - HPR (4)			
2 TRANS - AFW - PCS - FB (5)			
3 TRANS - AFW - PCS - EIHP (6)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event: If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Note:

1. The human error probability (HEP) assessed in the IPE for establishing bleed and feed is approximately 4E-3. It is assigned a credit of 2, based on survey of similar action at other W 2 loop plants.

Table 3.2 SDP Worksheet for Kewaunee Nuclear Power Plant — Transients (w/o PCS) (TPCS)

Estimated Frequency (Table 1 Row) _________ **Exposure Time _________** **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Secondary Heat Removal (AFW)	1/2 MDAFW trains (1 multi-train system) or 1/1 TDAFW train (1 ASD train) to 1/2 SGs with corresponding 1/1 ARV or 1/5 safety valves
Early Inventory, High Pressure Injection (EIHP)	1/2 HPSI pumps (1 multi-train system)
Primary Heat Removal, Feed/Bleed (FB)	1/2 PORVs open for Feed/Bleed (operator action = 2) [(1)]
High Pressure Recirculation (HPR)	1/2 HPSI pumps with 1/2 RHR pumps with operator action for switchover (operator action = 3)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 TPCS - AFW - HPR (3)			
2 TPCS - AFW - FB (4)			
3 TPCS - AFW - EIHP (5)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:
If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Note:

1. The human error probability (HEP) assessed in the IPE for establishing bleed and feed is approximately 4E-3. It is assigned a credit of 2, based on survey of similar actions at other W 2 Loop plants.

Table 3.3 SDP Worksheet for Kewaunee Nuclear Power Plant — Loss of Service Water (LOSW)[1]

Estimated Frequency (Table 1 Row) __________ **Exposure Time** __________ **Table 1 Result (circle): A B C D E F G H**			
<u>Safety Functions Needed</u>: **Secondary Heat Removal (AFW)[2]** **Charging Pumps (CHG)[3]**	**<u>Full Creditable Mitigation Capability for Each Safety Function</u>:** 1/1 MDAFW train (1 train) or 1/1 TDAFW train (1 ASD train) to 1/2 SGs with corresponding 1/1 ARV or 1/5 safety valves 1/3 Charging pumps (operator action = 3)		
<u>Circle Affected Functions</u>	**<u>Recovery of Failed Train</u>**	**<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>**	**<u>Sequence Color</u>**
1 LOSW - AFW (2)			
2 LOSW - CHG (3)			
Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event: If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.			

<u>Notes</u>:

1. Loss of SW results in loss of cooling to the component cooling heat exchangers, safety injection pumps, containment fan coolers, and diesel generators. The important secondary systems that will lose cooling are the feedwater pumps and turbine oil coolers. It also results in loss of room cooling of many plant areas. SW is the safety related cooling source to the station and instrument air compressors, but the

compressors are normally cooled by potable water system. Reactor trip occurs either because of a loss of the feedwater pumps or a manual trip due to loss of component cooling to the reactor coolant pump. The initiating event frequency is 1.2E-4 and it contributes 1.5% of the CDF.

2. SW is required for room cooling for AFW pump A which is not credited. SW backup to the AFW system is not available, and it is assumed that sufficient inventory is provided by CSTs and reactor water makeup storage tank to remove decay heat for 24 hours.

3. Success of this function requires either continued operation of 1 of 3 charging pumps for seal injection or operator action to start a charging pump within 30 minutes following a reactor trip.

Table 3.4 SDP Worksheet for Kewaunee Nuclear Power Plant — Loss of Component Cooling Water (LCCW [1])

Estimated Frequency (Table 1 Row) _________ Exposure Time _________ Table 1 Result (circle): A B C D E F G H

<u>Safety Functions Needed</u>:	**<u>Full Creditable Mitigation Capability for Each Safety Function</u>:**
Secondary Heat Removal (AFW)	1/2 MDAFW train (1 multi-train system) or 1/1 TDAFW train (1 ASD train)
Main Feedwater (MFW)	1/2 MFW trains (operator action = 3)
Charging Pumps (CHG)[2]	1/3 Charging pumps (operator action = 3)

<u>Circle Affected Functions</u>	**<u>Recovery of Failed Train</u>**	**<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>**	**<u>Sequence Color</u>**
1 LCCW - AFW - MFW (3)			
2 LCCW - CHG (4)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

<u>Notes</u>:

1. Loss of CCW results in loss of cooling to the reactor coolant pumps, the RHR heat exchangers, the RHR pumps, the safety injection pumps, and the containment spray pumps. Loss of CCW most likely results in manual trip because of loss of cooling to the RCPs. The IE frequency was 3.1E-3 and it contributes about 0.1% of the CDF.

2. Success of this function requires either continued operation of 1 of 3 charging pumps for seal injection or operator action to start a charging pump within 30 minutes following a reactor trip.

Table 3.5 SDP Worksheet for Kewaunee Nuclear Power Plant — Loss of one 125V DC Bus (LDC) [1]

Estimated Frequency (Table 1 Row) __________ **Exposure Time** __________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Secondary Heat Removal (AFW)	1/1 MDAFW trains (1train) [2]
Power Conversion System (PCS)	1/2 MFW trains with 1/2 condensate trains (operator action = 3)
Early Inventory, High Pressure Injection (EIHP)	1/1 HPSI pumps (1 train) [2]
Primary Heat Removal, Feed/Bleed (FB)	1/1 PORVs open for Feed/Bleed (operator action = 2)
High Pressure Recirculation (HPR)	1/1 HPSI pumps with 1/1 RHR pumps [2] (requires operator action for switchover; operator action = 3)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LDC - AFW - PCS - HPR (4)			
2 LDC - AFW - PCS - FB (5)			
3 LDC - AFW - PCS - EIHP (6)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:
If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. Loss of Train A 125V DC Bus results in loss of automatic function of both the MDAFW pump A and TDAFW pump. Loss of Train B 125V DC bus will result in loss of automatic function for MDAFW Pump B. Following the IPE, here Loss of Train A is considered. The IE frequency is 2.1E-2 and it contributes 2.5% of the CDF.

2. The redundant safety system components -- MDAFW pump, HPSI pump, and RHR pump, --may be started by local operation of supply breaker which is not credited here.

3. No separate ET is provided. Please refer to the TRANS tree.

Table 3.6 SDP Worksheet for Kewaunee Nuclear Power Plant — Loss of Instrument Air (LOIA) [(1)]

Estimated Frequency (Table 1 Row) _________	**Exposure Time** _________	**Table 1 Result (circle): A B C D E F G H**	
Safety Functions Needed: **Secondary Heat Removal (AFW)** **Main Feedwater (MFW)**	**Full Creditable Mitigation Capability for Each Safety Function:** 1/2 MDAFW train (1 multi-train system) or 1/1 TDAFW train (1 ASD train) 1/2 MFW trains (operator action = 2) [(2)]		
Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LOIA - AFW - MFW			
Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event: If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.			

Notes:

1. Loss of IA causes main feed water regulating valves to close resulting in a reactor trip. It causes loss of speed controller for 2 of 3 charging pumps. Feed and bleed is not credited in the IPE. The IE frequency is 1.4E-03/yr and it contributes 0.1% of the CDF.

2. IPE credits recovery of MFW. This action requires local operation of components, including FW bypass valves. As per the IPE, Emergency Operating Procedure FR-H.1, Response to Loss of Secondary Heat Sink, is entered via the critical safety function tree. The HEP is assessed at 8.24E-3; a credit of 2.

3. No separate ET is provided. Please refer to the TRANS tree with no FB capability. Also, recovery of MFW is represented for the PCS function.

Table 3.7 SDP Worksheet for Kewaunee Nuclear Power Plant Nuclear Plant — Small LOCA

Estimated Frequency (Table 1 Row) __________ **Exposure Time** __________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Early Inventory, HP Injection (EIHP)	1/2 HPSI pumps (1 multi-train system)
Secondary Heat Removal (AFW/MFW)	1/2 MDAFW trains (1 multi-train system) or 1/1 TDAFW train (1 ASD train) or 1/2 MFW trains with 1/2 condensate trains (operator action = 2)
RCS Cooldown/ Depressurization (RCSDEP)	Operator depressurizes RCS by pressurizer spray or 1/2 PORV and using SG dump valves (operator action = 2)
Primary Heat Removal, Feed and Bleed (FB)	1/2 PORVs open for Feed/Bleed (operator action = 2) (1)
Accumulators (ACC)	1/2 Accumulators (1 multi-train system)
Low Pressure Injection (LPI)	1/2 RHR pumps (1 multi-train system)
High Pressure Recirculation (HPR)	1/2 HPSI pumps with 1/2 RHR pumps with operator action for switchover (operator action = 3)
Low Pressure Recirculation (LPR)	1/2 RHR pumps taking suction from sump and discharging to vessel (operator action = 2)
Shutdown Cooling (SDC)	1/2 RHR pumps in SDC mode (operator action = 2)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 SLOCA - SDC (2)			
2 SLOCA - RCSDEP(2) - HPR (4)			
3 SLOCA - AFW/MFW - HPR (6)			

4 SLOCA - AFW/MFW - FB (7)			
5 SLOCA - EIHP - LPR (9)			
6 SLOCA - EIHP - LPI (10)			
7 SLOCA - EIHP - ACC (11)			
8 SLOCA - EIHP - RCSDEP[3] (12)			
9 SLOCA - EIHP - AFW/MFW (13)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. The human error probability (HEP) assessed in the IPE for establishing bleed and feed cooling is approximately 4E-3. It is assigned a credit of 2.

2. In Sequence 2, the accident is under control and the RCSDEP involves cooldown and depressurization to establish RHR entry conditions. Success of this sequence depends on operator action for SG cooldown, and charging for inventory control.

3. In Sequence 8, RCSDEP is accomplished by dumping steam from 1/ 2 SGs to provide RCS inventory by the accumulators and the LPI system.

Table 3.8 SDP Worksheet for Kewaunee Nuclear Power Plant Nuclear Plant — Stuck Open PORV (SORV)

Estimated Frequency (Table 1 Row) _________ **Exposure Time** _________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Early Inventory, HP Injection (EIHP)	1/2 HPSI pumps (1 multi-train system)
Isolation of Small LOCA (BLK)	The closure of the block valve associated with stuck open PORV (operator action = 1)
Secondary Heat Removal (AFW/MFW)	1/2 MDAFW trains (1 multi-train system) or 1/1 TDAFW train (1 ASD train) or 1/2 MFW trains with 1/2 condensate trains (operator action = 2)
RCS Cooldown/ Depressurization (RCSDEP)	Operator depressurizes RCS by pressurizer spray or 1/ 2 PORV and using SG dump valves (operator action = 2)
Primary Heat Removal, Feed and Bleed (FB)	Operator action using stuck-open PORV (operator action = 2) (1)
Accumulators (ACC)	1/2 Accumulator (1 multi-train system)
Low Pressure Injection (LPI)	1/2 RHR pumps (1 multi-train system)
High Pressure Recirculation (HPR)	1/2 HPSI pumps with 1/2 RHR pumps with operator action for switchover (operator action = 3)
Low Pressure Recirculation (LPR)	1/2 RHR pumps taking suction from sump and discharging to vessel (operator action = 2)
Shutdown Cooling (SDC)	1/2 RHR pumps in SDC mode (operator action = 2)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 SORV - BLK - SDC (2)			
2 SORV - BLK - RCSDEP(2) - HPR (4)			
3 SORV - BLK - AFW/MFW - HPR (6)			

4 SORV - BLK - AFW/MFW - FB (7)			
5 SORV - BLK - EIHP - LPR (9)			
6 SORV - BLK - EIHP - LPI (10)			
7 SORV - BLK - EIHP - ACC (11)			
8 SORV - BLK - EIHP - RCSDEP[3] (12)			
9 SORV - BLK - EIHP - AFW/MFW (13)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. The human error probability (HEP) assessed in the IPE for establishing bleed and feed cooling is approximately 4E-3. It is assigned a credit of 2.

2. In Sequence 2, the accident is under control and the RCSDEP involves cooldown and depressurization to establish RHR entry conditions. Success of this sequence depends on operator action for SG cooldown, and charging for inventory control.

3. In Sequence 8, RCSDEP is accomplished by dumping steam from 1/ 2 SGs to provide RCS inventory by the accumulators and the LPI system.

4. No separate ET is provided. Please refer to the SLOCA tree.

Table 3.9 SDP Worksheet for Kewaunee Nuclear Power Plant Nuclear Plant — Medium LOCA[1]

Estimated Frequency (Table 1 Row) __________ Exposure Time __________ Table 1 Result (circle): A B C D E F G H

Safety Functions Needed:	Full Creditable Mitigation Capability for Each Safety Function:
Early Inventory, HP Injection (EIHP)	1/2 HPSI pumps (1 multi-train system).
Auxiliary Feedwater (AFW/MFW)	1/2 MDAFW pumps (1 multi-train system) or 1/1 TDAFW pumps (1 ASD train) or 1/2 MFW trains with 1/2 condensate trains (operator action = 2) [2]
RCS Depressurization (RCSDEP)	Operator depressurizes and cools down using 1/2 SGs (operator action = 2)
Accumulator (EIAC)	1/1 ACC injection to one intact loop (1 train)
Low Pressure Injection (LPI)	1/2 RHR pumps (1 multi-train system)
High Pressure Recirculation (HPR)	1/2 HPSI pumps taking suction from 1/2 RHR pumps with operator action for switchover (operator action = 3)
Low Pressure Recirculation (LPR)	1/2 RHR pump trains with operator switchover from injection to recirculation (operator action = 2)

Circle Affected Functions	Recovery of Failed Train	Remaining Mitigation Capability Rating for Each Affected Sequence	Sequence Color
1 MLOCA - HPR (2)			
2 MLOCA - EIHP - LPR (4)			
3 MLOCA - EIHP - LPI (5)			
4 MLOCA - EIHP - RCSDEP (6)			

5 MLOCA - EIHP - AFW/MFW (7)			
6 MLOCA - EIHP - EIAC (8)			
Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event: If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.			

Notes:

1. MLOCA comprises break sizes ranging from 2 to 6 inches equivalent diameter.
2. Establishing MFW during a LOCA is assigned an error probability of approximately 8.0E-3; a credit of 2.

Table 3.10 SDP Worksheet for Kewaunee Nuclear Plant — Large LOCA

Estimated Frequency (Table 1 Row) __________ **Exposure Time __________** **Table 1 Result (circle): A B C D E F G H**

<u>Safety Functions Needed</u>:	**<u>Full Creditable Mitigation Capability for Each Safety Function</u>:**
Early Inventory, Accumulators (EIAC)	1/1 Accumulator to the intact loop (1 train)
Early Inventory, LP Injection (EILP)	1/2 RHR pump trains (1 multi-train system)
Low Pressure Recirculation (LPR)	1/2 RHR trains; Operator switchover from injection to recirculation (operator action = 2)

<u>Circle Affected Functions</u>	**<u>Recovery of Failed Train</u>**	**<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>**	**<u>Sequence Color</u>**
1 LLOCA - LPR (2)			
2 LLOCA - EILP (3)			
3 LLOCA - EIAC (4)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Table 3.11 SDP Worksheet for Kewaunee Nuclear Plant — Loss of Offsite Power (LOOP)

Estimated Frequency (Table 1 Row) __________ **Exposure Time __________** **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Emergency AC Power (EAC)	1/2 Emergency Diesel Generators (1 multi-train system) (1)
Turbine-driven AFW Pump Train (TDAFW)	1/1 TDP trains of AFW (1 ASD train)
Secondary Heat Removal (AFW)	1/2 MDAFW trains (1 multi-train system) or 1/1 TDAFW train (1 ASD train)
Motor-driven AFW Pump Train (MDAFW)	1/2 MDAFW trains (1 multi-train system)
Recovery of AC Power in < 3 hrs (REC3)	SBO procedures implemented (operator action = 1) (2)
Recovery of AC Power in < 11 hrs (REC11)	SBO procedures implemented (operator action = 2) (2,3)
Early Inventory, HP Injection (EIHP)	1/2 HPSI pumps (1 multi-train system)
Primary Heat Removal (FB)	Operator uses RCS pressurizer 1/2 PORVs (operator action = 2)
High Pressure Recirculation (HPR)	1/2 HPSI pumps with 1/2 RHR pumps and with operator action for switchover (operator action = 3)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LOOP - AFW - HPR (3)			
2 LOOP - AFW - FB (4)			
3 LOOP - AFW - EIHP (5)			
4 LOOP - EAC -TDAFW - HPR (9, 11) (AC recovered)			

5 LOOP - EAC - TDAFW - MDAFW -EIHP (AC recovered) (13)			
6 LOOP - EAC - REC11 (7)			
7 LOOP - EAC - TDAFW - MDAFW - FB (AC recovered) (12)			
8 LOOP - EAC - TDAFW - REC3 (14)			
Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event: If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.			

<u>Notes:</u>

1. In response to the Station Blackout rule, the TSC diesel generator in the plant would provide an alternate power source to the emergency 480V AC Bus 52 in case where offsite and onsite power are lost. However, the TSC diesel generator cannot be credited for the AC power recovery.

2. In the Kewaunee IPE, the probability of not restoring power in 3 hours is 2.65E-01 and that of not restoring power in 11 hours is 2E-02.

3. In Kewaunee, station batteries and auxiliary feedwater are assumed to be lost at 8 hours and core uncovery occurs around 3 hours following termination of auxiliary feedwater.

Table 3.12 SDP Worksheet for Kewaunee Nuclear Power Plant — LOOP with Loss of 1 EAC Bus (LEAC)[1]

Estimated Frequency (Table 1 Row) _________ **Exposure Time _________** **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Secondary Heat Removal (AFW)	1/1 MDAFW train (1 train) or 1/1 TDAFW train (1 ASD train) to 1/2 SGs with corresponding 1/1 ARV or 1/ 5 safety valves
Stuck-open Relief Valve (SORV)	Both PORVs reclose after opening during transient (1 train)
Early Inventory, High Pressure Injection (EIHP)	1/1 HPSI pumps (1 train)
Primary Heat Removal, Feed/Bleed (FB)	1/1 PORVs open for Feed/Bleed (operator action = 2) [2]
RCS Cooldown/ Depressurization (RCSDEP)	Operator depressurizes RCS using stuck open PORV and using SG dump valves (operator action = 2)
High Pressure Recirculation (HPR)	1/1 HPSI pumps with 1/1 RHR pumps with operator action for switchover (operator action = 3)
Low Pressure Recirculation (LPR)	1/1 RHR pumps taking suction from the sump (operator action = 2)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LEAC - AFW - HPR (3)			
2 LEAC - AFW - FB (4)			

3 LEAC - AFW - EIHP (5)			
4 LEAC - SORV - LPR (7)			
5 LEAC - SORV - RCSDEP - HPR (9)			
6 LEAC - SORV - EIHP (10)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. In this worksheet, LOOP with loss of 1 emergency AC or associated EDG which is not covered in the LOOP worksheet is addressed. It is conservatively assumed that if the PORV fails to reclose its associated block valve will not be available due to loss of the associated AC bus. One division of all the safety systems are assumed to be affected by this initiator. The initiating event frequency is assumed to be two orders of magnitude lower than the LOOP frequency.

2. The human error probability (HEP) assessed in the IPE for establishing bleed and feed is approximately 4E-3.

3. Sequences 4, 5, and 6 above are not modeled in the IPE. These are included here as a consistent approach for similar plants comparing similar SDP worksheets.

Table 3.13 SDP Worksheet for Kewaunee Nuclear Plant — Steam Generator Tube Rupture (SGTR)

Estimated Frequency (Table 1 Row) __________ **Exposure Time** __________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Secondary Heat Removal (AFW) [(1)]	1/1 MDAFW train (1 multi-train system) or 1/1 TDAFW train (1 ASD Train)
Early Inventory, HP Injection (EIHP)	1/2 HPSI pumps (1 multi-train system)
Main Feedwater (MFW)	1/2 MFW trains with 1/2 condensate trains (operator action = 2)
SG Isolation (SGI)	Operator isolates the ruptured SG (operator action = 3) [(2)]
Pressure Equalization (EQ)	Operator cools down RCS using 1/1 SG PORV (on unaffected SG) and depressurizes RCS with 1/2 PORVs to less than setpoint of relief valves of SG (operator action = 2) [(3)]
Decay Heat Removal (DHR)	Operator cools down and depressurization of primary and aligning 1/2 RHR pumps (operator action = 2)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 SGTR - EQ - DHR (3, 10)			
2 SGTR - SGI - DHR (5, 12)			
3 SGTR - EIHP - DHR (7, 14)			
4 SGTR - AFW - MFW (15)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event: If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

<u>Notes</u>:

1. Kewaunee SGTR analysis credits the recovery of main feedwater if auxiliary feedwater fails, but does not credit the use of feed and bleed if all feedwater fails. Because of KNPP's design, only 2 AFW pumps, 1 motor driven and 1 turbine driven, can provide flow to 1 SG once the other SG is isolated.

2. Failure to isolate ruptured SG and stop TDAFW flow is assigned an error probability of 8.4E-4.

3. Failure to cooldown and depressurize for SGTR is assigned a failure probability of 1.5E-2.

Table 3.14 SDP Worksheet for Kewaunee Nuclear Plant — Main Steam Line Break (MSLB) (1)

Estimated Frequency (Table 1 Row) __________ **Exposure Time** __________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Early Inventory, HP Injection (EIHP)	1/2 HPSI pumps (1 multi-train system)
Secondary Heat Removal (AFW/MFW)	1/1 MDAFW (2) (1 train) or 1/1 TDP of AFW (1 ASD Train) or 1/2 MFW trains with 1/2 condensate trains (operator action = 2)
Main Steam Isolation (ISOL)	Automatic signal for 2/2MSIV closure, isolation of both feedwater lines and operator verification (1 train)
Feed / Bleed (FB)	1/2 PORVs open for feed/bleed (operator action = 2)
High Pressure Recirculation (HPR)	1/2 HPSI pumps taking suction from RHR pumps (operator action = 3)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 MSLB - AFW/MFW - HPR (3,9)			
2 MSLB - AFW /MFW - FB (4,10)			
3 MSLB - EIHP - AFW/MFW (6)			
4 MSLB - EIHP - ISOL (11)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:
If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. This initiator in the Kewaunee IPE covers large steam line breaks and large feed line breaks.

2. Because of KNPP's design, only 2 AFW pumps, 1 motor-driven and 1 turbine-driven, can provide flow to 1 SG once the other SG is isolated. Therefore, once the faulty SG is isolated only 2 AFW pumps are available.

Table 3.15 SDP Worksheet for Kewaunee Nuclear Plant — Anticipated Transients Without Scram (ATWS)[1]

Estimated Frequency (Table 1 Row) __________ Exposure Time __________ Table 1 Result (circle): A B C D E F G H

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Emergency Boration, Long Term Shutdown (LTS)	Emergency boration using 2/3 charging pumps with 2/2 boric acid transfer pumps (operator action = 2)
ATWS Mitigation System Actuation Circuitry (AMSAC)	AMSAC trips the turbine and starts AFW pumps (1 train)
Primary Relief (PR)	2/2 SRVs with 1/2 PORVs open (1 train)
Secondary Heat Removal (AFW)	2/2 MD AFW pumps or 1/1 TD AFW pump to at least 1/2 SG (1 multi-train system)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 ATWS - PR (3)			
2 ATWS - AFW (4)			
3 ATWS - LTS (2)			
4 ATWS - AMSAC (5)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event: If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Note:

1. In the Kewaunee model, it is conservatively assumed that MFW is not available following the initiator.

Table 3.16 SDP Worksheet for Kewaunee Nuclear Power Plant — Interfacing System LOCA (ISLOCA)[1]

Estimated Frequency (Table 1 Row) _________	**Exposure Time** _________	**Table 1 Result (circle): A B C D E F G H**	
Initiating Pathways:	**Mitigation Capability: Ensure Component Operability for Each Pathway:**		
RHR Suction Line	Two MOVs in series: RHR 1A and 2A or RHR 1B and 2B		
RHR Return to the RCS Line	Two Check Valves in series		
Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Pathway**	**Sequence Color**
Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:			
If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.			

Note:

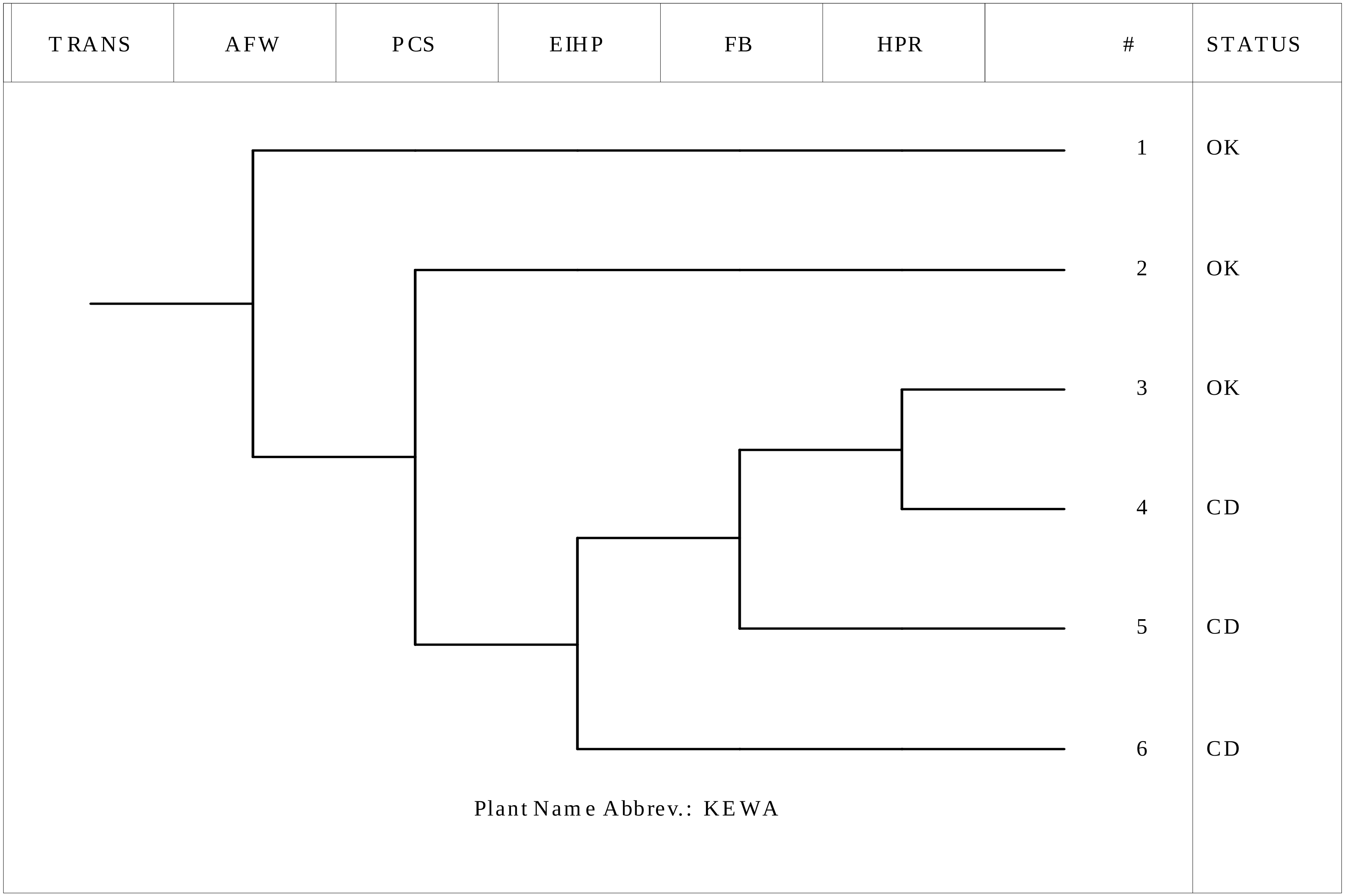
1. Information is provided based on the licensee's comments and input. Other sources of ISLOCA are not included due to very low likelihood of occurrence.

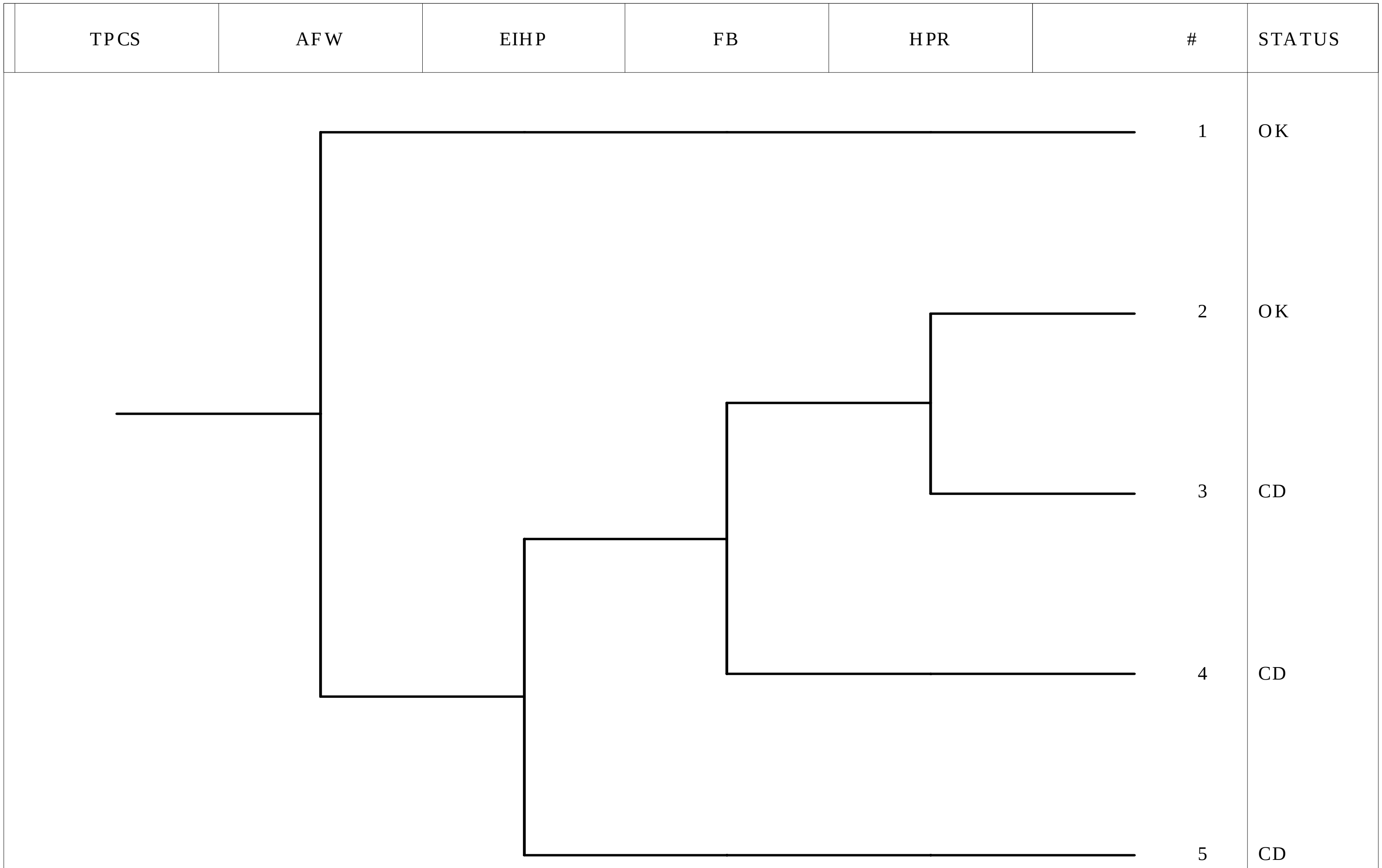
1.4 SDP EVENT TREES

This section provides the simplified event trees called SDP event trees used to define the accident sequences identified in the SDP worksheets in the previous section. An event tree for the stuck-open PORV is not included since it is similar to the small LOCA event tree. The event tree headings are defined in the corresponding SDP worksheets.

The following event trees are included:

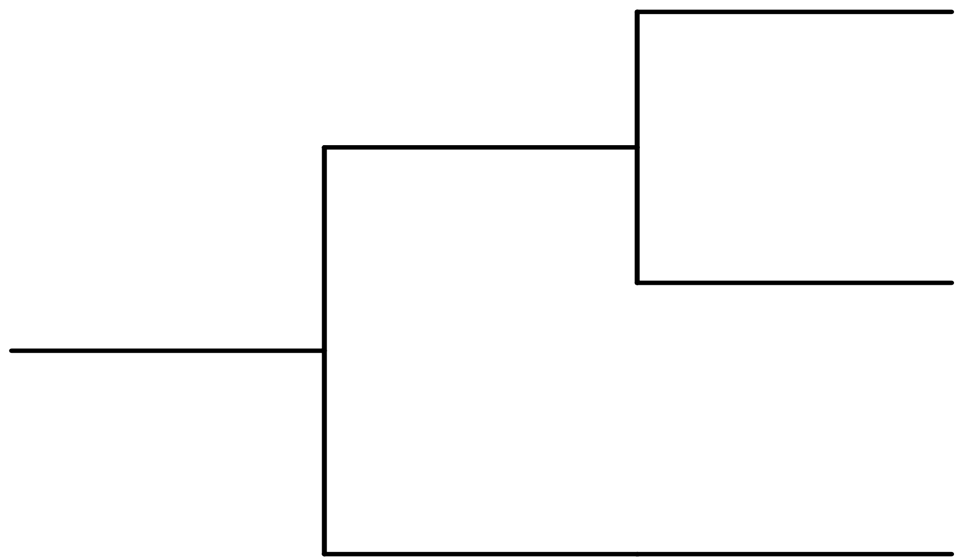
1. Transients (Reactor Trip) (TRANS)
2. Transients w/o PCS (TPCS)
3. Loss of Service Water (LOSW)
4. Loss of Component Cooling Water (LCCW)
5. Small LOCA (SLOCA)
6. Medium LOCA (MLOCA)
7. Large LOCA (LLOCA)
8. Loss of Offsite Power (LOOP)
9. LOOP with 1 EAC Bus (LEAC)
10. Steam Generator Tube Rupture (SGTR)
11. Main Steam Line Break (MSLB)
12. Anticipated Transients Without Scram (ATWS)


TRANS
AFW
PCS
EIHP
FB
HPR
#
STATUS
1
OK
2
OK
3
OK
4
CD
5
CD
6
CD
Plant Name Abbrev.: KEWA

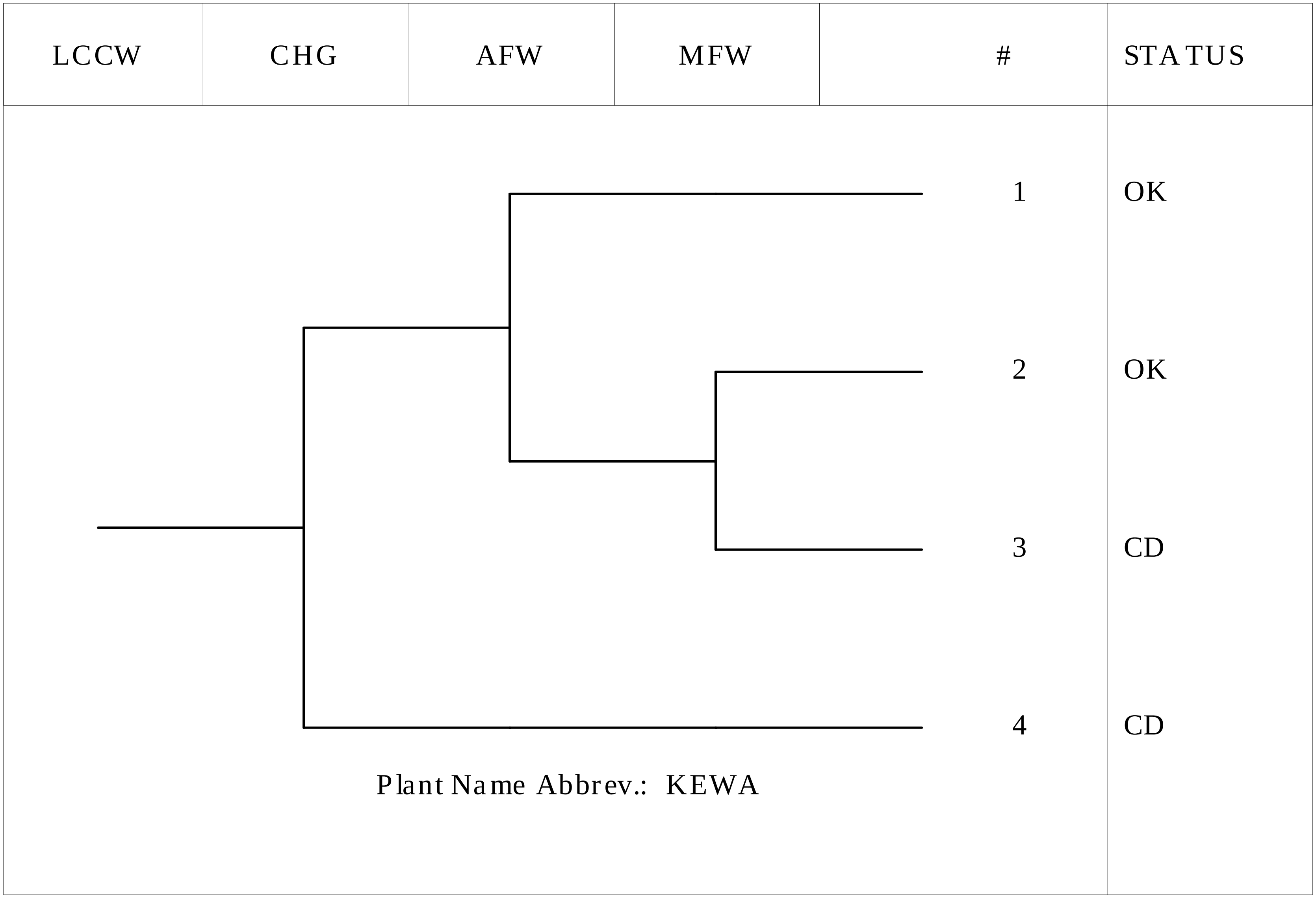


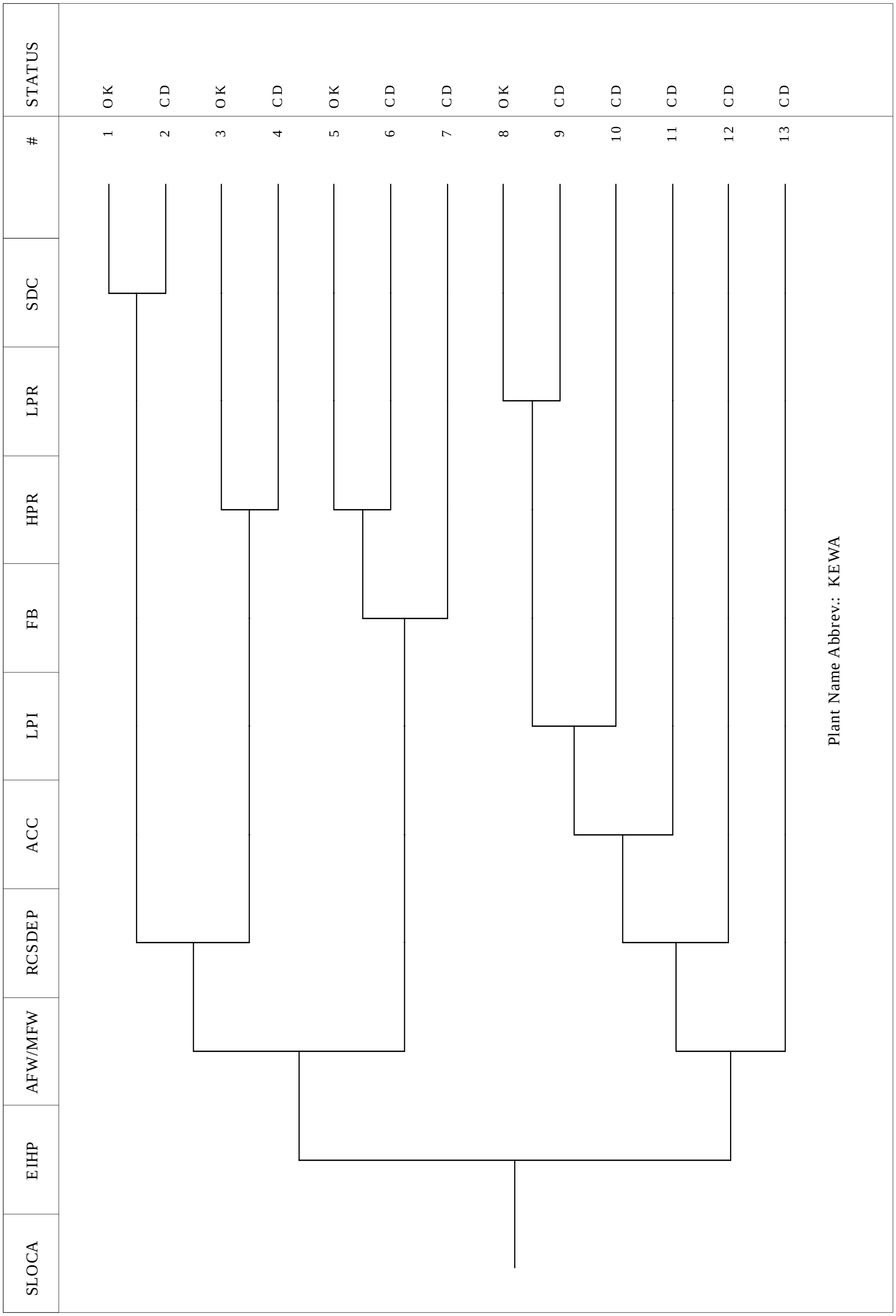
Plant Name Abbrev.: KEWA

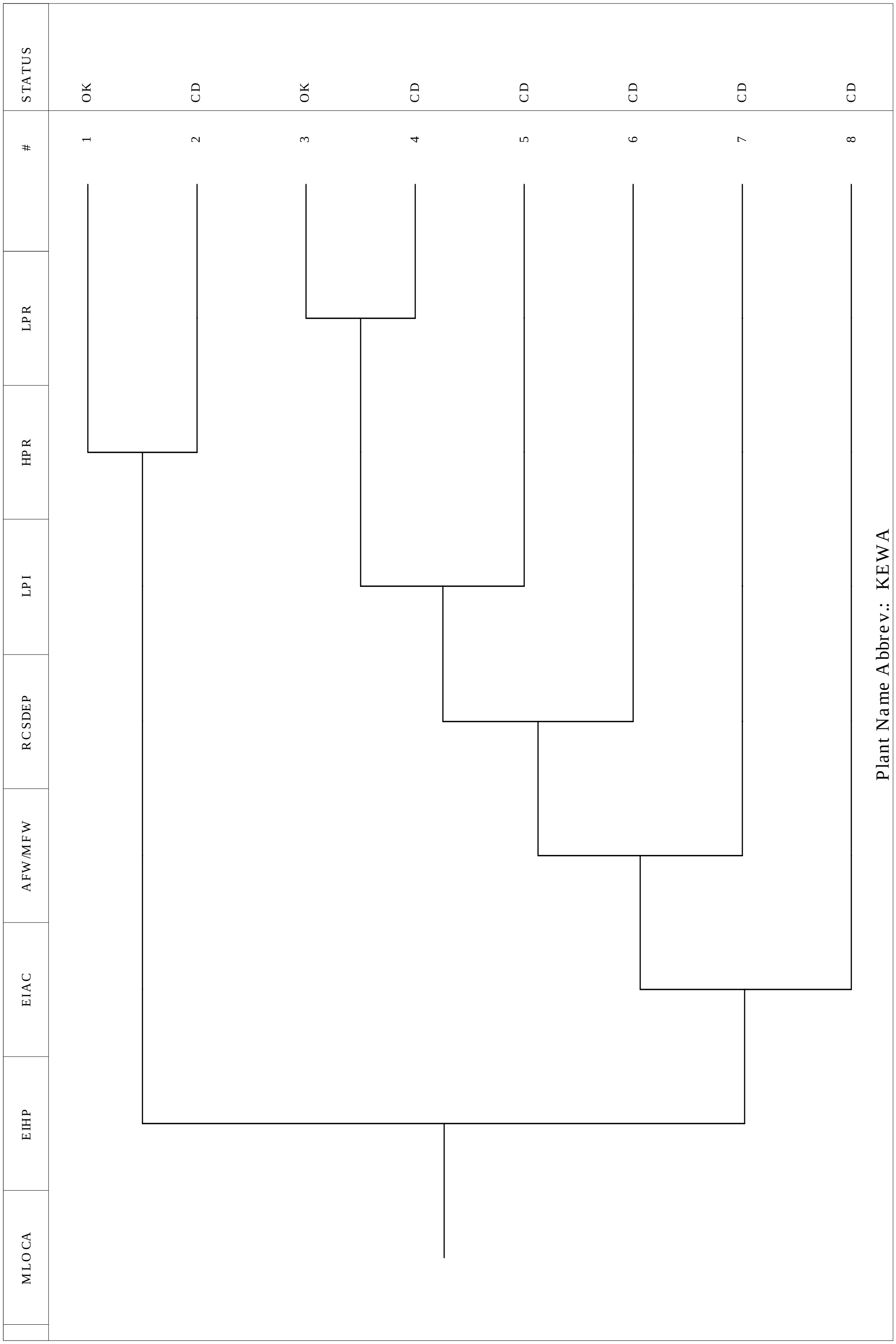
LOSW	CHG	AFW	#	STATUS
			1	OK
			2	CD
			3	CD



Plant Name Abbrev.: KEWA


LCCW
CHG
AFW
MFW
#
STATUS
1
OK
2
OK
3
CD
4
CD
Plant Name Abbrev.: KEWA


SLOCA
EIHP
AFW/MFW
RCSDEP
ACC
LPI
FB
HPR
LPR
SDC
#
STATUS
1 OK
2 CD
3 OK
4 CD
5 OK
6 CD
7 CD
8 OK
9 CD
10 CD
11 CD
12 CD
13 CD
Plant Name Abbrev.: KEWA


STATUS
#
LPR
HPR
LPI
RCSDEP
AFW/MFW
EIAC
EIHP
MLOCA
1 OK
2 CD
3 OK
4 CD
5 CD
6 CD
7 CD
8 CD
Plant Name Abbrev.: KEWA

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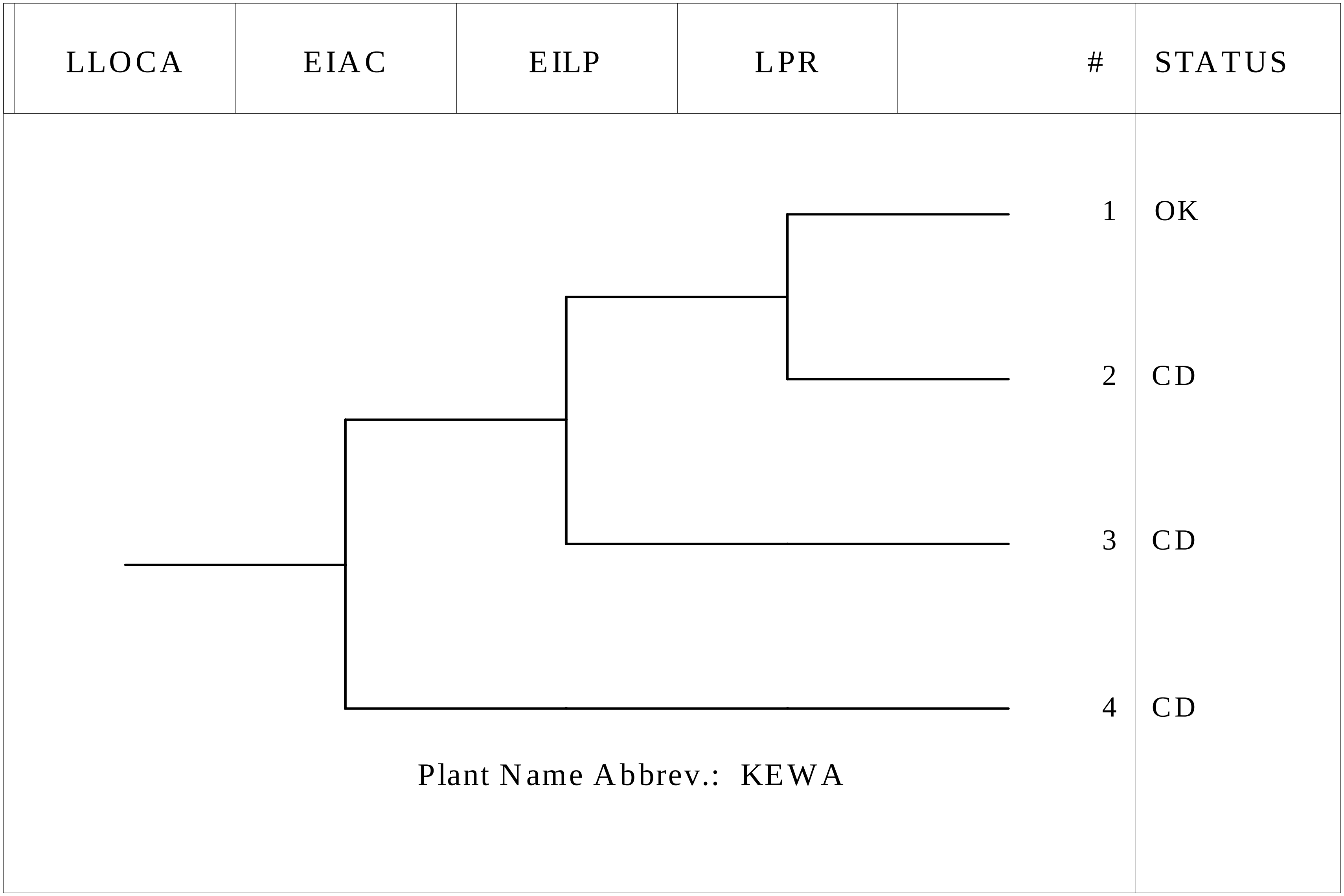
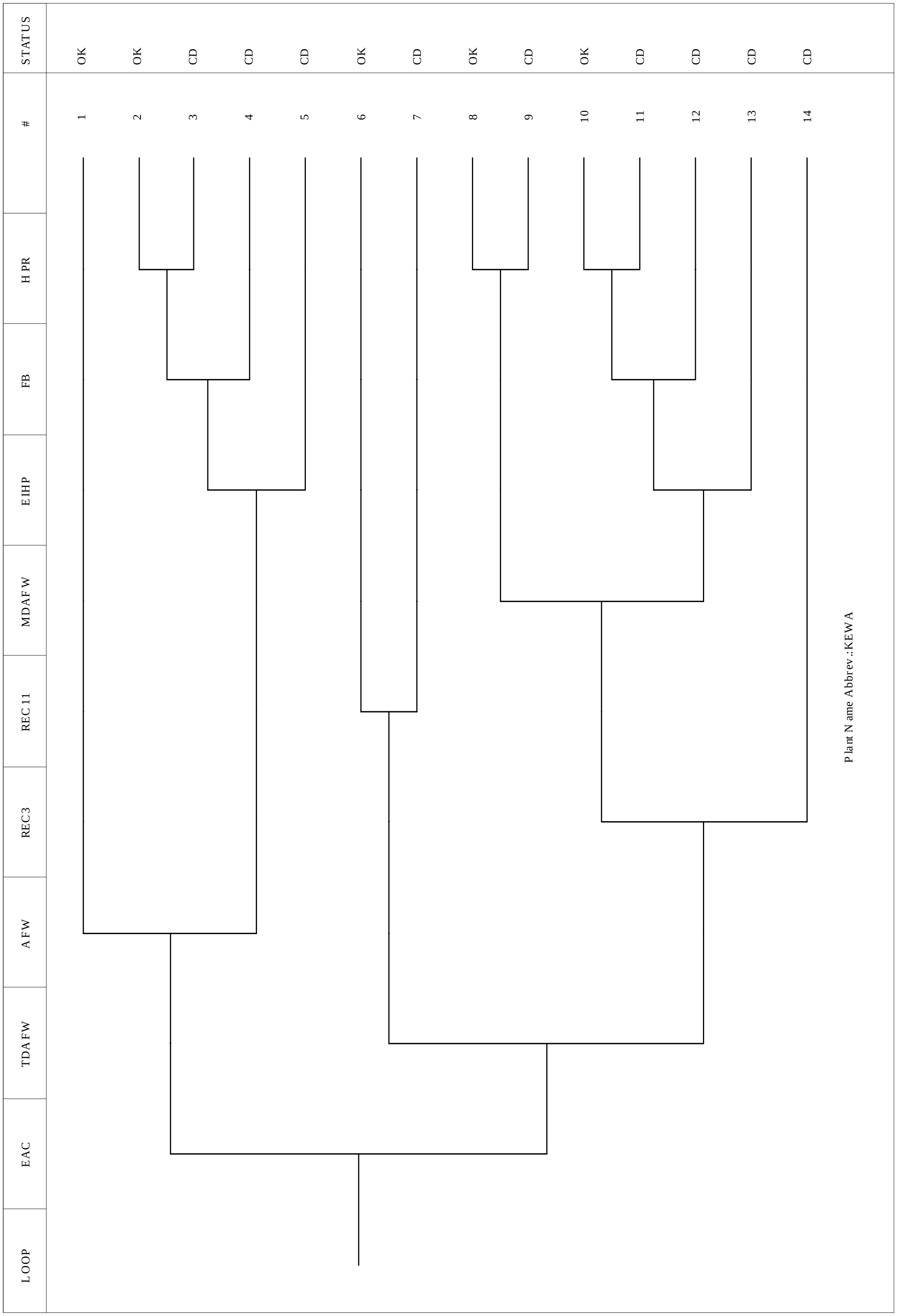

LLOCA
EIAC
EILP
LPR
#
STATUS
1 OK
2 CD
3 CD
4 CD
Plant Name Abbrev.: KEWA


STATUS
#
HPR
FB
EIHP
MDAFW
REC11
REC3
AFW
TDAFW
EAC
LOOP
OK
OK
CD
CD
CD
OK
CD
OK
CD
OK
CD
CD
CD
CD
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Plant Name Abbrev.:KEWA

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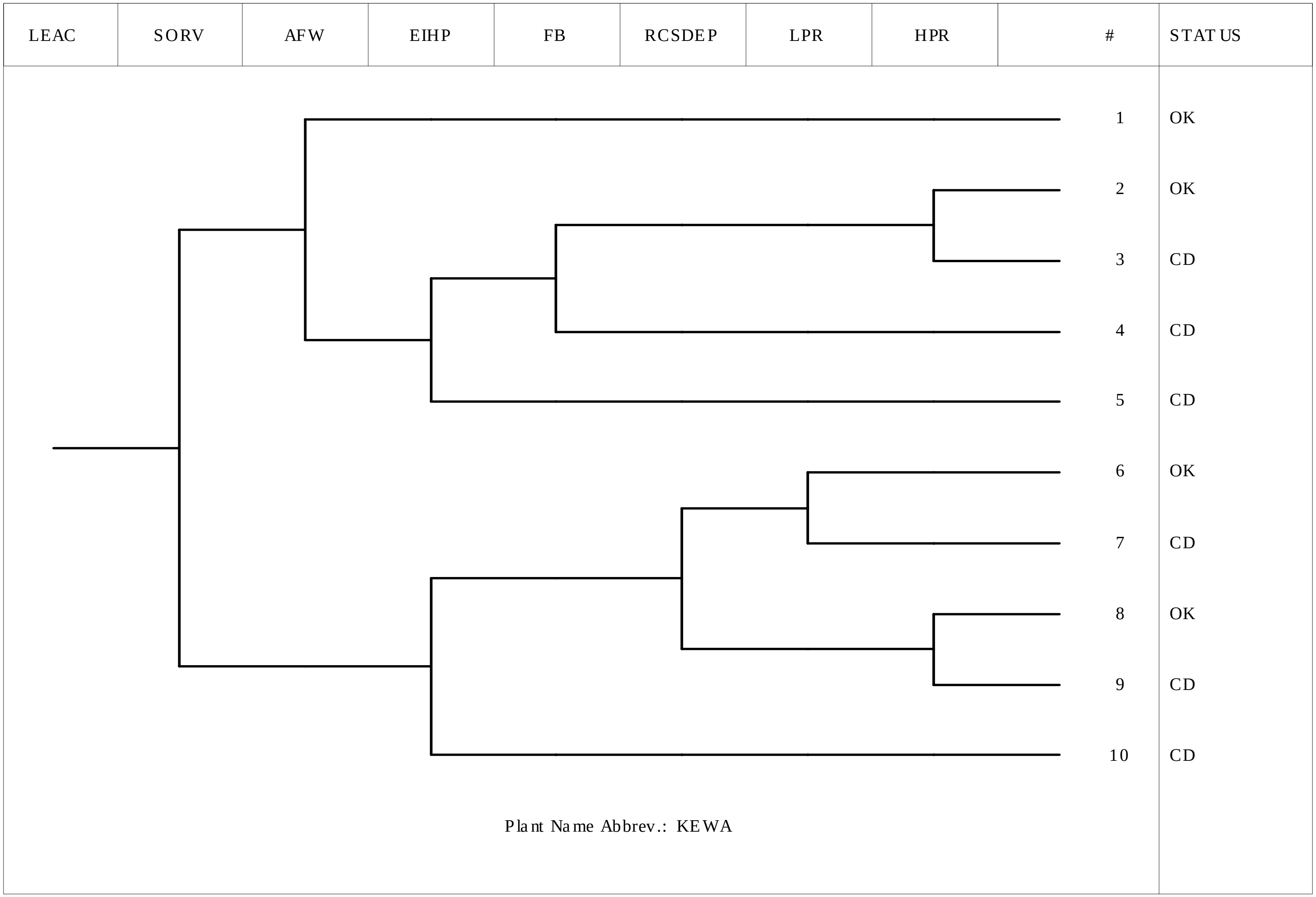
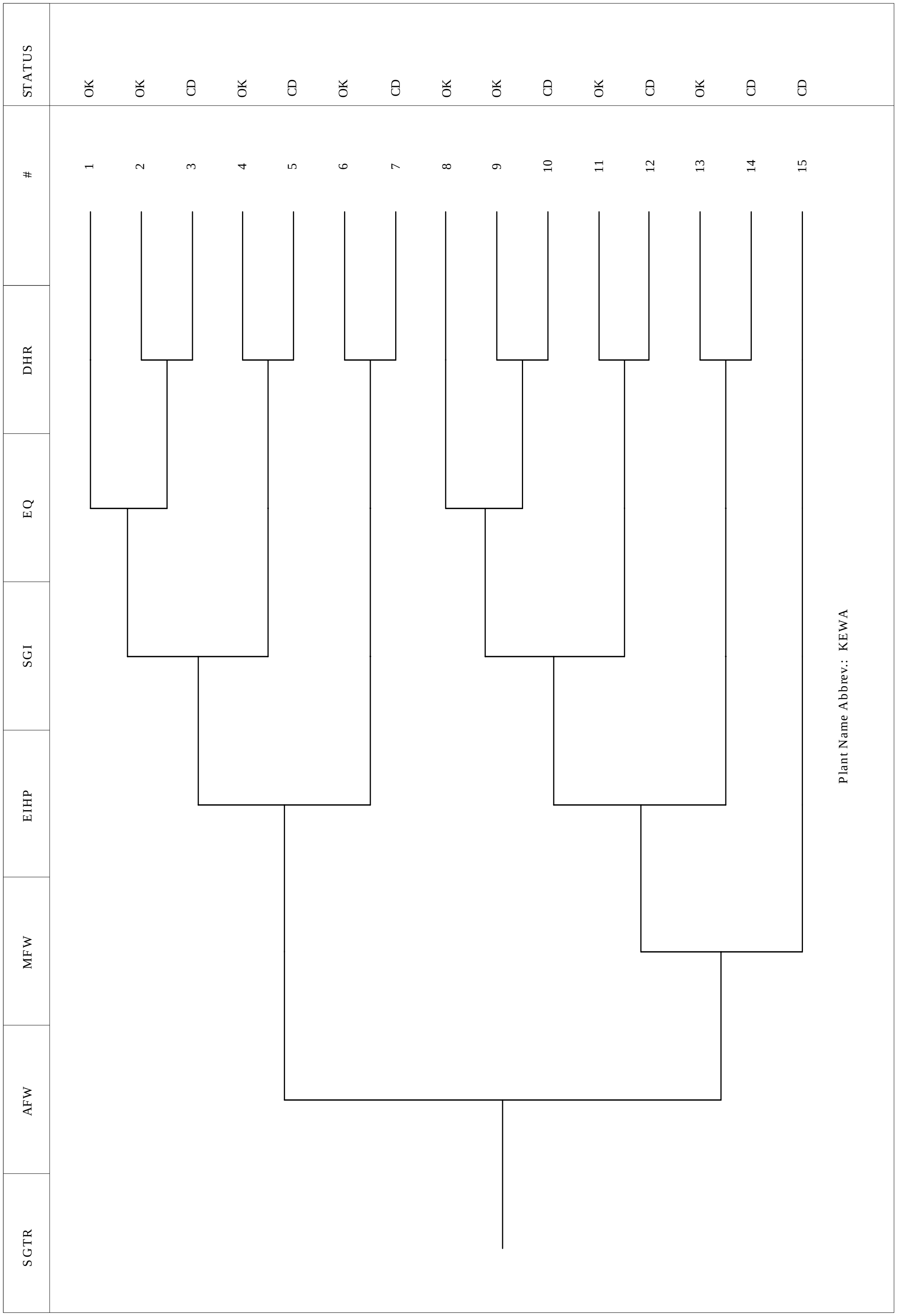

LEAC
SORV
AFW
EIHP
FB
RCSDEP
LPR
HPR
#
STATUS
1 OK
2 OK
3 CD
4 CD
5 CD
6 OK
7 CD
8 OK
9 CD
10 CD
Plant Name Abbrev.: KEWA


STATUS
#
DHR
EQ
SGI
EIHP
MFW
AFW
SGTR
1 OK
2 OK
3 CD
4 OK
5 CD
6 OK
7 CD
8 OK
9 OK
10 CD
11 OK
12 CD
13 OK
14 CD
15 CD
Plant Name Abbrev.: KEWA

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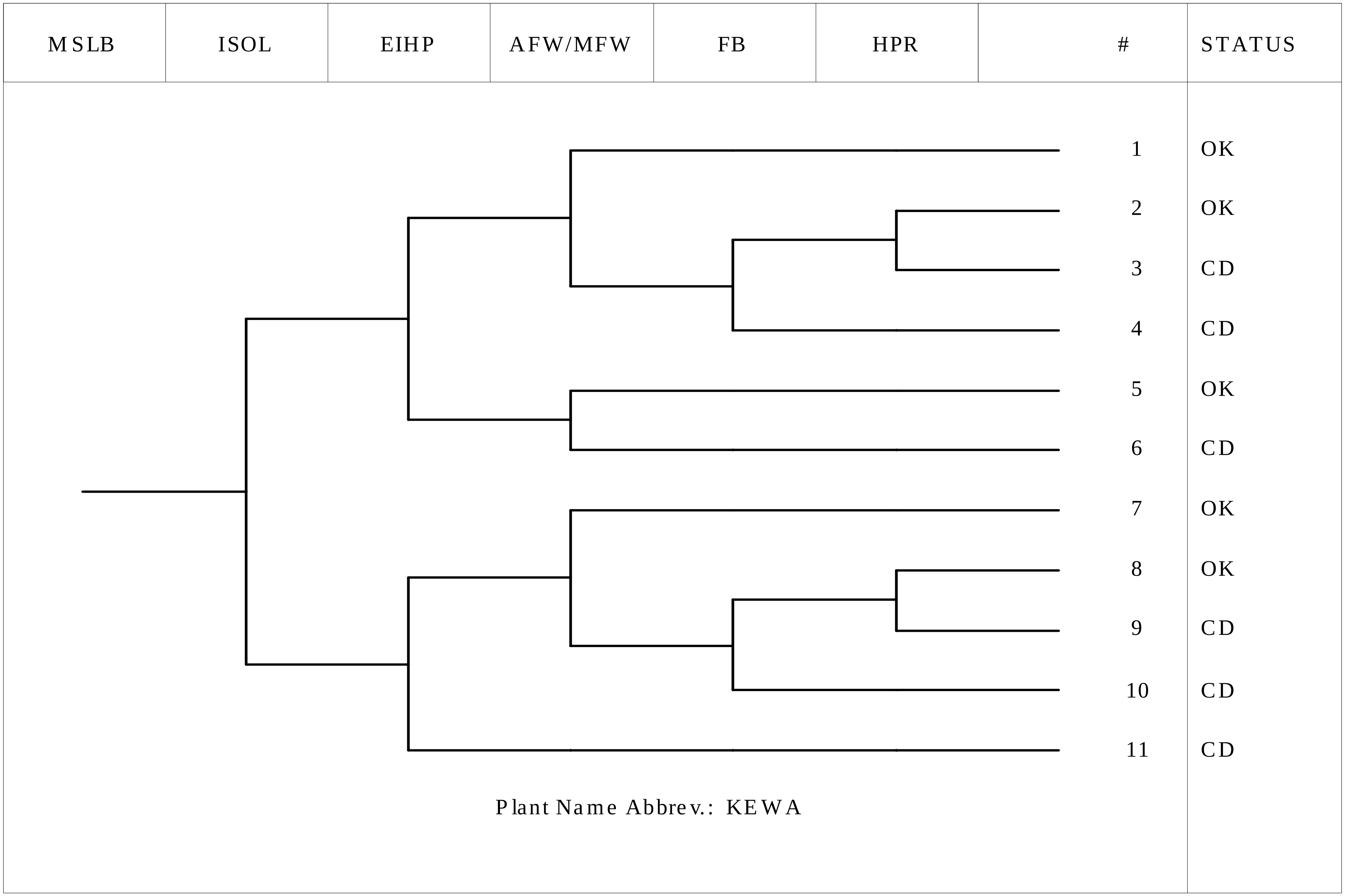
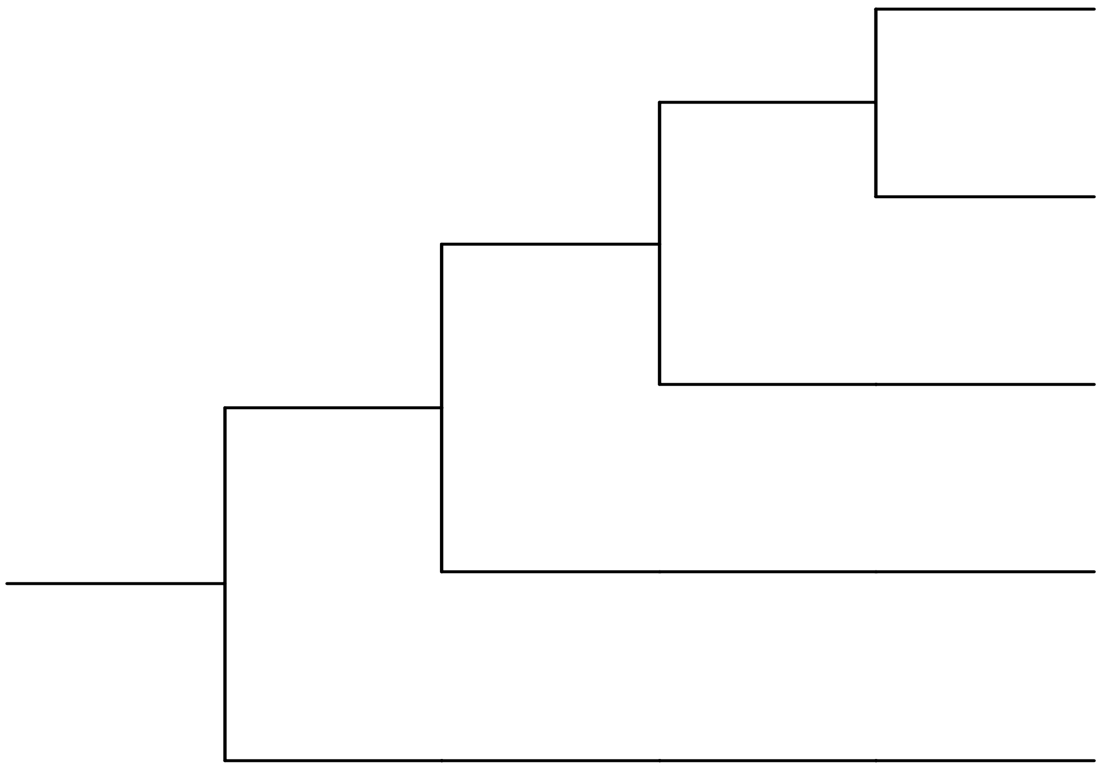

MSLB
ISOL
EIHP
AFW/MFW
FB
HPR
#
STATUS
1 OK
2 OK
3 CD
4 CD
5 OK
6 CD
7 OK
8 OK
9 CD
10 CD
11 CD
Plant Name Abbrev.: KEWA



ATWS	AMSAC	AFW	PR	LTS	#	STATUS
					1	OK
					2	CD
					3	CD
					4	CD
					5	CD

Plant Name Abbrev.: KEWA

2. RESOLUTION AND DISPOSITION OF COMMENTS

This section is composed of two subsections. Subsection 2.1 summarizes the generic assumptions that were used for developing the SDP worksheets for the PWR plants. These guidelines were based on the plant-specific comments provided by the licensee on the draft SDP worksheets and further examination of the applicability of those comments to similar plants. These assumptions which are used as guidelines for developing the SDP worksheets help the reader better understand the worksheets' scope and limitations. The generic guidelines and assumptions for PWRs are given here. Subsection 2.2 documents the plant-specific comments received on the draft version of the material included in this notebook and their resolution.

2.1 GENERIC GUIDELINES AND ASSUMPTIONS (PWRs)

The following generic guidelines and assumptions were used in developing the SDP worksheets for PWRs. These guidelines and assumptions were derived from a review of the licensee's comments, the resolutions of those comments, and the applicability to similar plants.

1. Assignment of plant-specific IEs into frequency rows:

Transient (Reactor trip) (TRANS), transients without PCS (TPCS), small, medium, and large LOCA (SLOCA, MLOCA, LLOCA), inadvertent or stuck-open PORV/SRV (SORV), main steam and feedwater line break (MSLB), anticipated transients without scram (ATWS), and interfacing system LOCAs (ISLOCA) are assigned into rows based on a consideration of the industry-average frequency. Plant-specific frequencies are considered for loss of offsite power (LOOP) and special initiators, and are assigned to the appropriate rows in Table 1.

2. Stuck open PORV/SRV as an IE in PWRs:

This event typically is not modeled in PRAs/IPEs as an initiating event. The failure of the PORVs/SRVs to re-close after opening is typically modeled within the transient event trees subsequent to the initiators. In addition, the intermittent failure or excessive leakage through PORVs as an initiator, albeit with much lower frequency, needed to be considered. To account for such failures and to keep the transient worksheets simple in the SDP, a separate worksheet for the SORV initiator was set up to explicitly model the contribution from such failures. This SDP worksheet, and the associated event tree, is similar to that of SLOCA. The frequency of PORV to re-close depends on the status of pressurizer. If the pressurizer is solid, then the frequency would be higher than the case in which the pressurizer level is maintained. Typically, this depends on early availability of secondary heat removal. However, the frequency for the SORV initiator is generically estimated for all PWR plants in Table 1.

3. Inclusion of special initiators:

The special initiators included in the worksheets are those applicable to this plant. A separate worksheet is included for each of them. The applicable special initiators are primarily based on the plant-specific IPEs/PRAs. In other words, the special initiators included are those modeled in the IPEs/PRAs unless shown to be negligible contributors. In some cases, a particular special initiator may be added for a plant even if it is not included in the IPE/PRA, if it is included in other plants of similar design, and is considered applicable for the plant. However, no attempt is made at this time to have a consistent set of special initiators across similarly designed plants. Except for the interfacing system LOCA (ISLOCA), if the occurrence of the special initiator results in a core damage, i.e., no mitigation capability exists for the initiating event, then a separate worksheet is not developed. For such cases, the inspection's focus is on the initiating event and the risk implication of the finding can be directly assessed. For ISLOCA, a separate worksheet is included noting the pathways that can lead to it.

4. Inclusion of systems under the support system column of the Initiators and System Dependency Table:

This Table shows the support systems for the support- and frontline systems. The intent is to include only the support systems, and not the systems supporting that support system, i.e., those systems whose failure will result in failure of the system being supported. Partial dependency, e.g., a backup system, is not included. If they are, this should be so noted. Sometimes, some subsystems on which inspection findings may be noted were included as a support system, e.g., the EDG fuel oil transfer pump as a support system for EDGs.

5. Coverage of system/components and functions included in the SDP worksheets:

The Initiators and System Dependency Table includes systems and components which are included in the SDP worksheets and those which can affect the performance of these systems and components. One-to-one matching of the event tree headings/functions to that included in the Table was not considered necessary.

6. Crediting of non-safety related equipment:

SDP worksheets credit or include safety-related equipment and also, non-safety related equipment, as used, in defining the accident sequences leading to core damage. In defining the success criteria for the functions needed, the components included are those covered under the Technical Specifications (TS) and the Maintenance Rule (MR). Credits for other components may have been removed in the SDP worksheets.

7. No credit for certain plant-specific mitigation capability:

The significance determination process (SDP) screens inspection findings for Phase 3 evaluations. Some conservative assumptions are made which result in not crediting some plant-specific features. Such assumptions are usually based on comparisons with plants of similar design, and they help to maintain consistency across the SDP worksheets for similar plant designs.

8. Crediting system trains with high unavailability:

Some system component/trains may have unavailability higher than 1E-2, but they are treated similarly to other trains with lower unavailability in the range of 1E-2. In this screening, this approach is considered adequate to keep the process simple. An exception is made for steam-driven components which are designated as Automatic Steam Driven (ASD) train with a credit of 1E-1.

9. Treating passive components (of high reliability) the same as active components:

Passive components, namely accumulators, are credited similarly to active components, even though they exhibit higher reliability. Considering the potential for common-cause failures, the reliability of a passive system is not expected to differ by more than an order of magnitude from active systems. Pipe failures were excluded, except as part of initiating events where the appropriate frequency is used. Accordingly, a separate designation for passive components was not considered necessary.

10. Crediting accumulators:

SDP worksheets assume the loss of the accumulator unit associated with the failed leg in LOCA scenarios. Accordingly, in defining the mitigation capability for the accumulators, the worksheets refer to the remaining accumulators. For example, in a plant with 4 accumulators with a success criteria of 1 out of 4, for large LOCA the mitigation capability is defined as 1/3 remaining accumulators (1 multi-train system), assuming the loss of the accumulator in the failed leg. For a plant with a success criteria of 2 out of 4 accumulators, the mitigation capability is defined as 2/3 remaining accumulators (1 multi-train system).

The inspection findings are then assessed as follows (using the example of the plant with 4 accumulators and success criteria of 2 out of 4):

4 Acc. Available	Credit=3
3 Acc. Available (1 Acc. is considered unavailable, based on inspection findings)	Credit=2
< 3 Acc. Available (2 or more Acc. are considered unavailable, Based on inspection findings)	Credit=0

11. Crediting operator actions:

The operator's actions modeled in the worksheets are categorized as follows: operator action=1 representing an error probability of 5E-2 to 0.5; operator action=2 representing an error probability of 5E-3 to 5E-2; operator action=3 representing an error probability of 5E-4 to 5E-3; and operator action=4 representing an error probability of 5E-5 to 5E-4. Actions with error probability > 0.5 are not credited. Thus, operator actions are associated with credits of 1, 2, 3, or 4. Since there is large variability in similar actions among different plants, a survey of the error probability across plants of similar design was used to categorize different operator actions. From this survey, similar actions across plants of similar design are assigned the same credit. If a plant uses a lower credit or recommends a lower credit for a particular action compared to our assessment of similar action based on plant survey, then the lower credit is assigned. An operator's action with a credit of 4, i.e., operator action=4, is noted at the bottom of the worksheet; the corresponding hardware failure, e.g., 1 multi-train system, is defined in the mitigating function.

12. Difference between plant-specific values and SDP designated credits for operator actions:

As noted, operator actions are assigned to a particular category based on a review of similar actions for plants with similar design. This results in some differences between plant-specific values and credit for the action in the worksheet. The plant-specific values are usually noted at the bottom of the worksheet.

13. Dependency among multiple operator actions:

IPEs or PRAs, in general, account for dependencies among the multiple operator actions that may be applicable. In the SDP screening approach, if multiple actions are involved in one function, then the credit for the function is designated as one operator action to the extent possible, considering the dependency involved.

14. Crediting the standby high-pressure pump:

The high-pressure injection system in some plants consists of three pumps with two of them auto-aligned and the third spare pump requiring manual action. The mitigating capability then is defined as : 1/ 2 HPI trains or use of a spare pump (1 multi-train system). Also, a footnote is added to reflect that the use of a spare pump could be given a credit of 1 (i.e.,1E-1) as a recovery action.

15. Emergency AC Power:

The full mitigating capability for emergency AC could include dedicated Emergency Diesel Generators (EDG), Swing EDG, SBO EDG, and finally, nearby fossil-power plants. The following guidelines are used in the SDP modeling of the Emergency AC power capability:

a) Describe the success criteria and the mitigation capability of dedicated EDGs.

b) Assign a mitigating capability of “operator action=1" for a swing EDG. The SDP worksheet assumes that the swing EDG is aligned to the other unit at the time of the LOOP (in a sense a dual unit LOOP is assumed). The operator, therefore, should trip, transfer, re-start, and load the swing EDG.

c) Assign a mitigating capability of “operator action=1" for an SBO EDG similar to the swing EDG. Note, some of the PWRs do not take credit for an SBO EDG for non-fire initiators. In these cases, credit is not given.

d) Do not credit the nearby power station as a backup to EDGs. The offsite power source from such a station could also be affected by the underlying cause for the LOOP. As an example, overhead cables connecting the station to the nuclear power plant also could have been damaged due to the bad weather which caused the LOOP. This level of detail should be left for a Phase 3 analysis.

16. Treatment of HPR and LPR:

The operation of both the HPR and LPR rely on the operation of the RHR pumps and the associated heat exchangers. Therefore, failure of LPR could imply failure of both HPR and LPR. A sequence which contains failure of both HPR and LPR as independent events will significantly underestimate the CDF contribution. To properly model this configuration within the SDP worksheets, the following procedure is used. Consider the successful depressurization and use of LPR as the preferred path. HPR is credited when depressurization has failed. In this manner, a sequence containing both HPR and LPR failures together is not generated.

17. SGTR event tree:

Event trees for SGTR vary from plant to plant depending on the size of primary-to-secondary leak, SG relief capacity, and the rate of rapid depressurization. However, there are several common functional steps that are addressed in the SDP worksheet: early isolation of the affected SG, initiation of primary cool-down and depressurization, and prevention of the SG overfill. These actions also include failure to maintain the secondary pressure below that of Main Steam safety valves which could occur either due to the failure of the relief valves to open or the operator's failure to follow the procedure. Failure to perform this task (sometimes referred to as early isolation and equalization) is assumed to cause continuous leakage of primary outside the containment. The success of this step implies the need for high-pressure makeup for a short period, followed by depressurization and cooldown for RHR entry (note, relief valves are assumed to re-close when primary pressure falls below that of the secondary). If the early makeup is not available or the operator fails to perform early isolation and equalization, rapid depressurization to RHR entry is usually assumed. This would typically require some kind of intermediate- or low-pressure makeup. Finally, depending on the size of the Refueling Water Storage Tank (RWST), sometimes it would be necessary to establish makeup to the RWST to allow sufficient time to enter the RHR mode.

18. ATWS scenarios:

The ATWS SDP worksheet assumes that these scenarios are not recoverable by operator actions, such as a manual trip. The failure of the scram system, therefore, is not recoverable, neither by the actuation of a back-up system nor through the actuation of manual scram. The initiator frequency, therefore, should only account for non-recoverable scrams, such as mechanical failure of the scram rods.

19. Recovery of losses of offsite power:

Recovery of losses of offsite power is assigned an operator-action category even though it is usually dominated by a recovery of offsite AC, independent of plant activities. Furthermore, the probability of recovery of offsite power in "X" hours (for example 4 hours) given it is not recovered earlier (for example, in the 1st hour) would be different from recovery in 4 hours with no condition. The SDP worksheet uses a simplified approach for treating recovery of AC by denoting it as an operator action=1 or 2 depending upon the HEP used in the IPE/PRA. A footnote highlighting the actual value used in the IPE/PRA is provided, when available.

20. RCP seal LOCA in a SBO:

The RCP seal LOCA in a SBO scenario is included in the LOOP worksheet. RCP seal LOCA resulting from loss of support functions is considered only if the loss of support function is a special initiator. The dependencies of RCP seal cooling are identified in Table 2.

21. RCP Seal LOCA for Westinghouse Plants during SBO Scenarios:

The modeling of the RCP seal failures upon loss of cooling and injection as occurs during SBO scenarios has been the subject of many studies (e.g., BNL Technical Report W6211-08/99 and NUREG/CR-4906P). These studies are quite complex and assign probabilities of seal failure as a function of time (duration of SBO) and the associated leak rates. The leak rates, in turn, will determine what would be the safe period for recovery of the AC source and the use of SI pumps before core uncovery and damage. On the contrary, the SDP worksheets simplify the analysis of the RCP seal LOCA during the SBO scenarios using the following two assumptions: (1) The probability of catastrophic RCP seal failure is assumed to be 1 if the SBO lasts beyond two hours, and (2) Given a catastrophic seal LOCA, the available time prior to core damage for recovery of offsite power and establishing injection is about two hours. Therefore, in almost all cases, to prevent a core damage, a source of AC should be recovered within 4 hours in SBO scenarios.

22. Tripping the RCP on loss of CCW:

Upon loss of CCW, the motor cooling will be lost. The operation of RCPs without motor cooling could result in overheating and failure of bearings. Bearing failure, in turn, could cause the shaft to vibrate and thereby result in the potential for seal failure if the RCP is not tripped. In Westinghouse plants, the operator is instructed to trip the RCPs early in the scenario (from 2 to 10 minutes after detecting the loss of cooling). Failure to perform this action is conservatively assumed to result in seal failure and, potentially, in a LOCA. This failure mechanism (occurrence of seal LOCA) due to failure to trip the RCPs upon loss of cooling is not considered likely in some plants, whereas it has been modeled explicitly in other plants. To ensure consistency, the trip of the RCP pumps are modeled in the SDP worksheets, and the operator failure to do this is assumed to result in a LOCA. In many cases, the failure to trip RCP following a loss of CCW results in core damage.

23. Hot leg/Cold leg switchover:

The hot leg to cold leg switchover during ECCS recirculation is typically done to avoid boron precipitation. This is typically part of the procedure for PWRs during medium and large LOCA scenarios. Some IPEs/PRAs do not consider the failure of this action as relevant to core damage. For plants needing the hot /cold switchover, it usually can only be accomplished with SI pumps and the ECCS recirculation also uses the SI pumps.

2.2 RESOLUTION OF PLANT-SPECIFIC COMMENTS

The comments received on an earlier version of the notebook are addressed as stated below. In addition, generic guidelines and assumptions provided above are used to address plant-specific comments and to assure consistency across plants of similar design.

1. Initiators and System Dependency Table

The licensee's comments on this table are used to modify the table.

2. Combining Early Injection, High Pressure Injection (EIHP) and Primary Heat Removal, Feed & Bleed (FB) functions into a single function

The licensee recommended that EIHP and FB functions are combined into a single FB function since feed and bleed involves using HPSI pumps and the PORVs. However, following the convention used for these notebooks, these functions are not combined. In some cases, e.g., SLOCA and SORV worksheets, automatic function of HPSI pumps is included and EIHP is defined as a function. It is considered that in other worksheets, i.e., in transients, combining EIHP with FB can be confusing.

REFERENCES

1. NRC SECY-99-007A, Recommendations for Reactor Oversight Process Improvements (Follow-up to SECY-99-007), March 22, 1999.

2. Wisconsin Public Service Corporation, "Kewaunee Nuclear Power Plant Individual Plant Examination Summary Report," December 1, 1992.

3. Wisconsin Public Service Corporation, "Kewaunee Nuclear Power Plant Response to generic Letter 88-20, Individual Plant Examination", November 11, 1993.