GSI-191: Analysis of Recovery Options

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ATTACHMENT 6

Basic Assumptions

- **Accident sequences as in NUREG/CR-6771**
  - Quantified recovery actions
  - Event tree and fault tree analysis
  - Human Reliability Analysis (ASEP)
- **Modeled after a typical PWR cooling system**
- **Cooling must be maintained for 24 hours**
- **Results given in technical letter LA-UR-02-7562**

Recovery Options

- **Continue ECCS Recirculation Cooling**
  - Recirculation pumps continue operation despite loss of NPSH
  - Actions are taken to restore NPSH and reestablish ECCS recirculation cooling
- **Switch to injection cooling with alternate source of water**

Continued Operation of ECCS Pumps

- **Pumps may operate with loss of NPSH**
- **Failure probability**
  - No data available – engineering judgment
  - LLOCA – 0.8
  - MLOCA – 0.5
  - SLOCA – 0.4 (Open PORV, LOFW)
- **Testing should be done to see if this is a viable recovery option**

Restore Recirculation Cooling

- **Operator must diagnose need**
  - Recognize symptoms of recirculation loss
  - Instruments must alert operator
- **Operator must act to restore recirculation**
  - Adjust flows
  - Use backflush system (if available)
- **Pumps must continue operating after recovery**

Continued ECCS Recirculation

- **Failure probability**
  - LLOCA – 0.46
  - MLOCA – 0.16
  - SLOCA – 0.025 (Open PORV, LOFW)
- **Driven by**
  - 1. Pump failure with loss of NPSH
  - 2. Operator failures

Human Reliability Analysis (HRA)

- Based on Accident Sequence Evaluation Program (ASEP) methodology (NUREG/CR-4772)
- ASEP used to provide screening values for postulated diagnosis and post-accident actions
- Judgments were made regarding time available for operator actions and corresponding stress levels
- Some credit given for HRA recovery factors (RFs)

Reestablish Injection

- **Operator must diagnose need to switch**
- **Switch must be successful**
  - Operator executes change
  - ECCS components operate
- **RWST must be refilled**
  - Spent fuel pool
  - Mixing water and boric acid from CVCS
  - Alternate RWST where available
  - Large LOCA – time for one of three methods

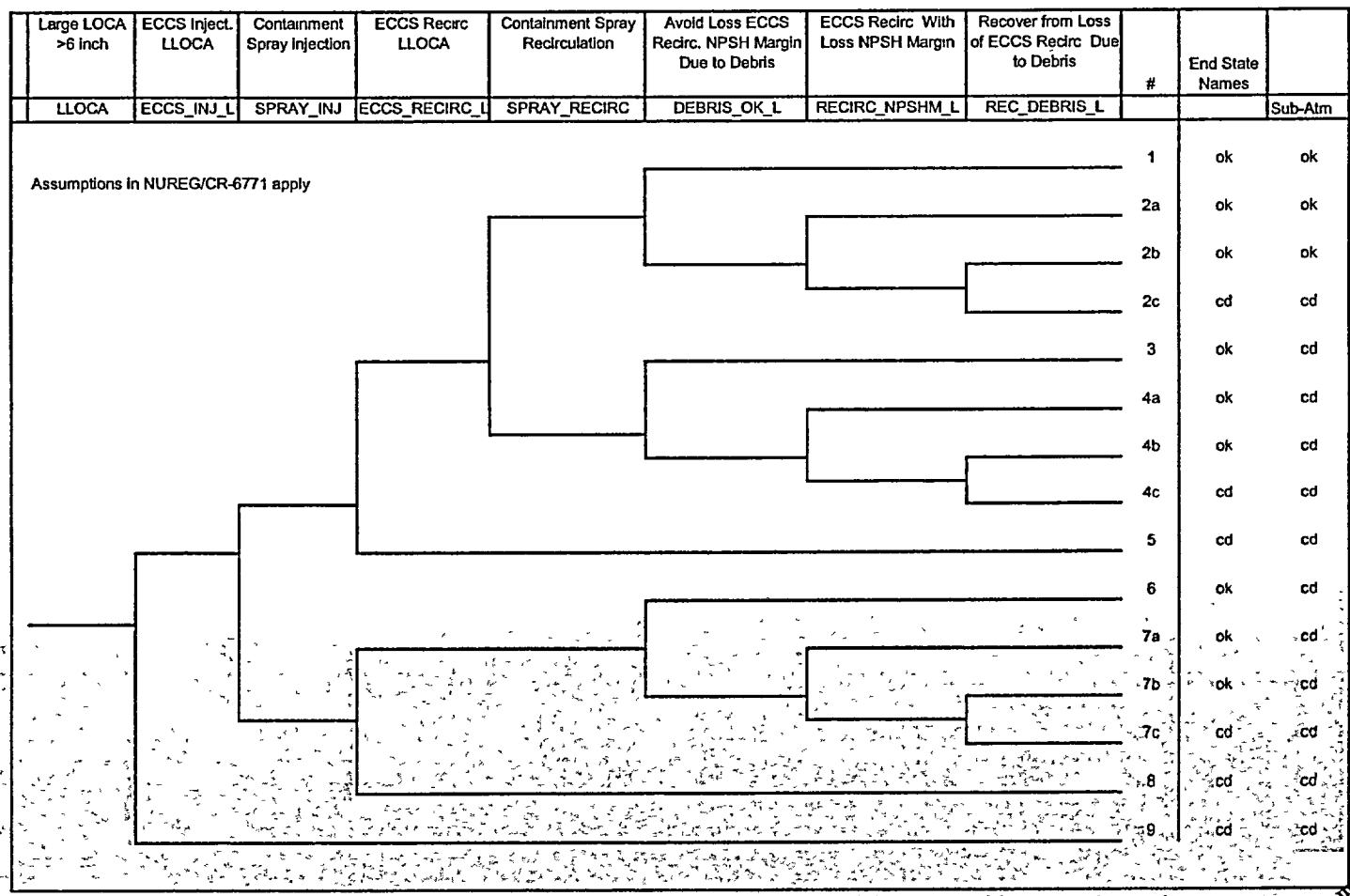
Reestablish Injection Cooling

- **Failure probability**
  - LLOCA – 0.87
  - MLOCA – 0.37
  - SLOCA – 0.045 (Open PORV, LOFW)
- **Driven by**
  - Operator failure – high stress, short time

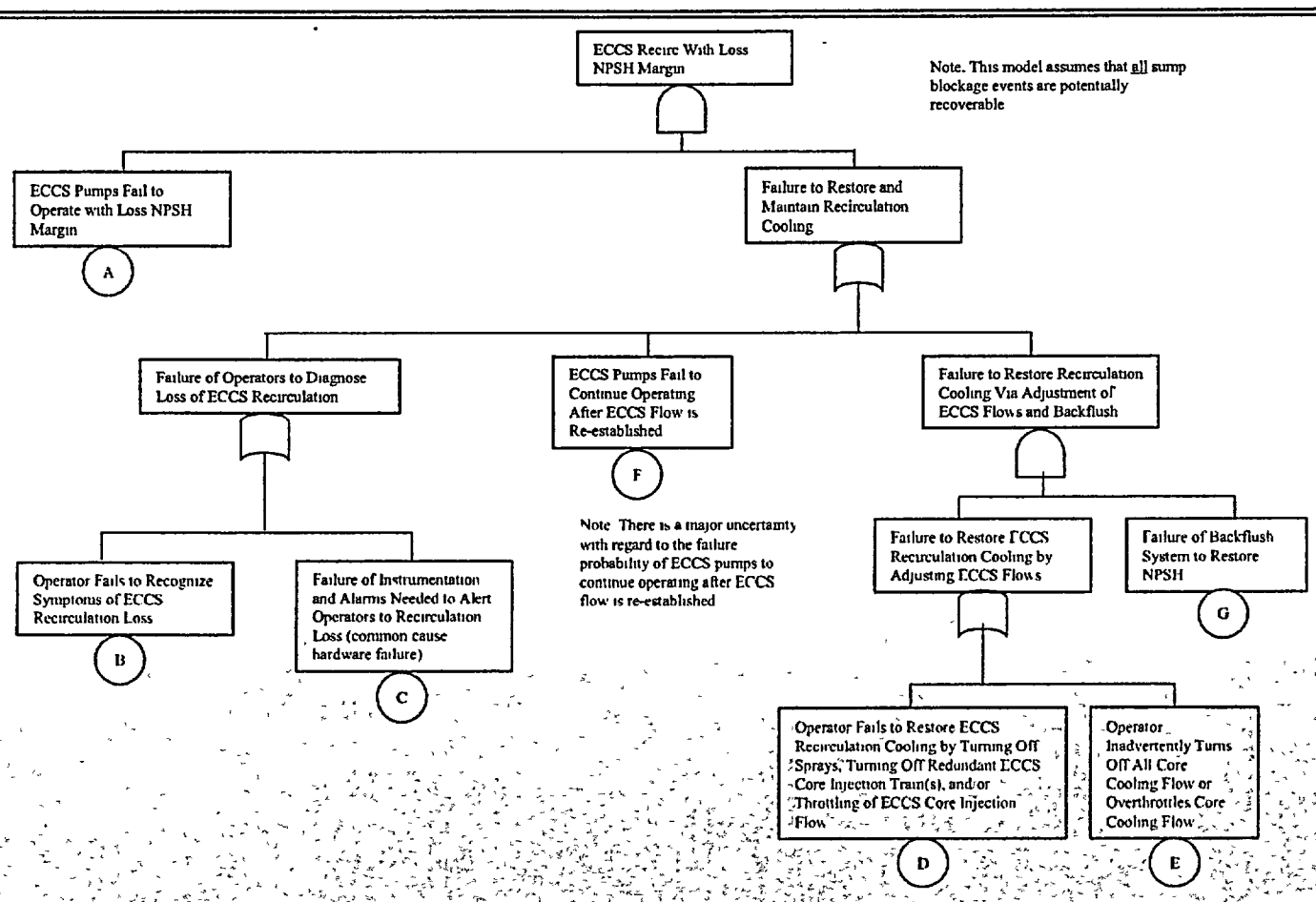
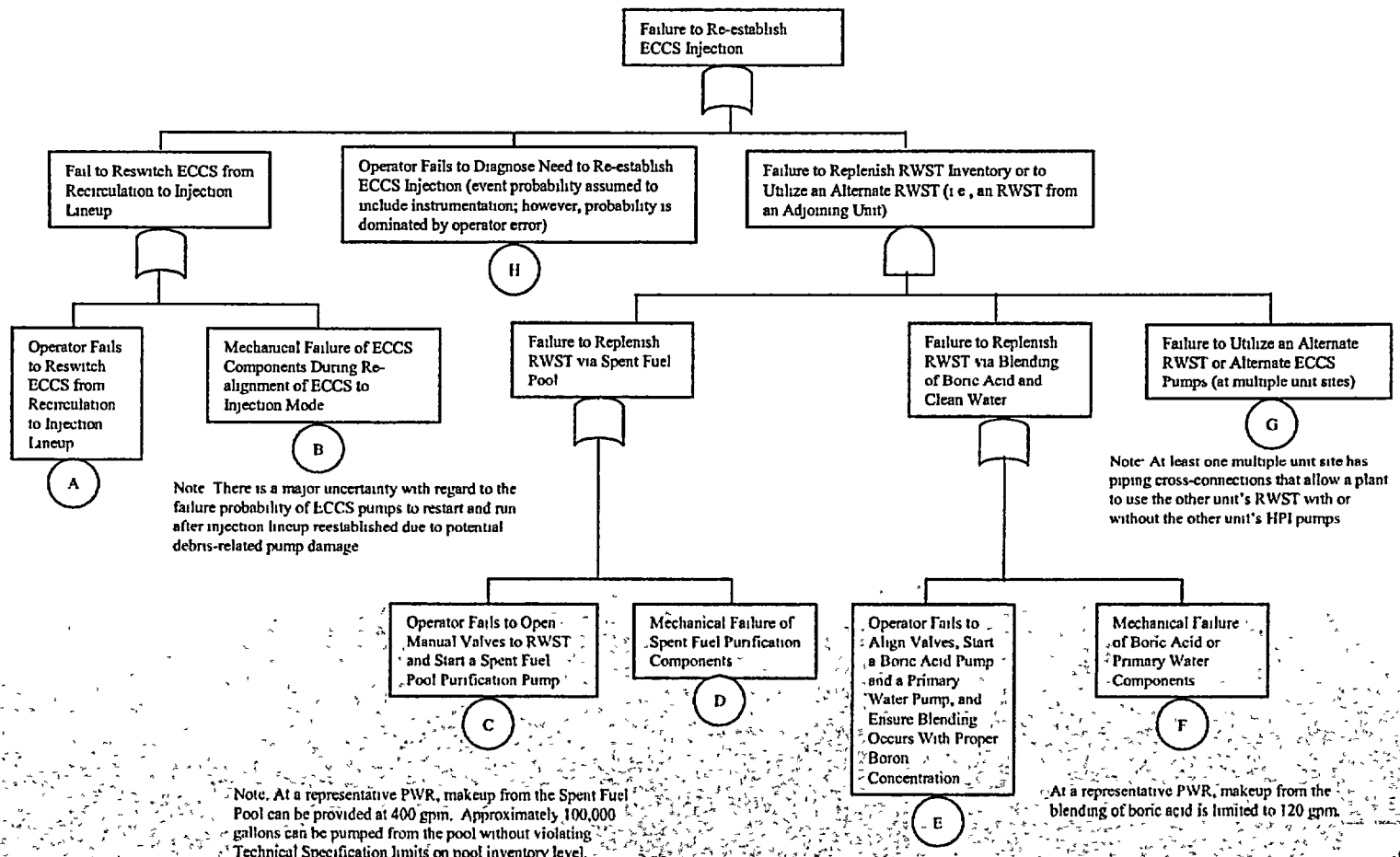
CDF Associated with LOCA Events

- **Traditional initiating event frequencies:**
  - Debris effects – 138 factor increase from no debris
  - With recovery – 19 factor increase from no debris
- **Leak before break initiating event frequencies**
  - Debris effects – 45 factor increase from no debris
  - With recovery – 2 factor increase from no debris
- **Increase warrants plant-specific studies**

Sample Event Tree - LLOCA



Fault Tree – ECCS Recirc.



Fault Tree – ECCS injection