Quantifying Reactor Accident Risk: A History

Panel W20: The Metamorphosis to a More Risk-Informed Regulator

Tom Wellock
NRC

Risk-Informed, Performance-Based

- A "New Paradigm"
  - Efficiency
  - Safety Significant
  - Relieve Regulatory Burden
- PRAs: "Significant Limitations"
  - Industry-NRC gap
  - Methodology
  - Data
  - Peer Review
- New Safety Issues

NRC Chairman Shirley Jackson

Three Ds of the Deterministic Era

- Deterministic Design
- Design Basis Accidents
- Defense-in-Depth
  - Inherent Safety
  - Active Systems
  - Siting
  - Static Layers (containment)

July 20, 1953

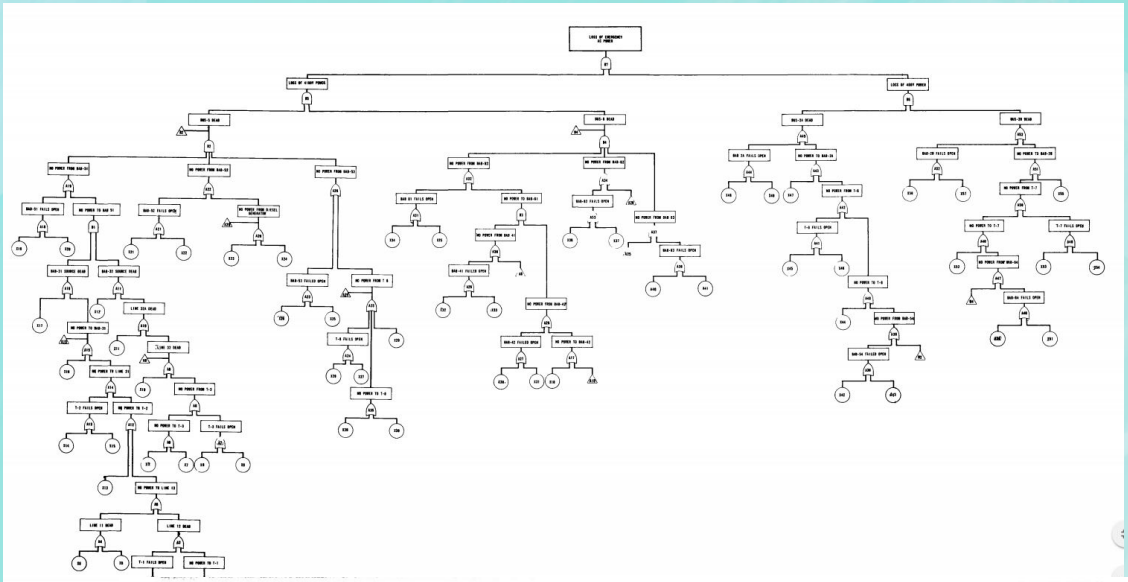
A. B. Greninger, Manager
Engineering Department
703 Building, 700 Area

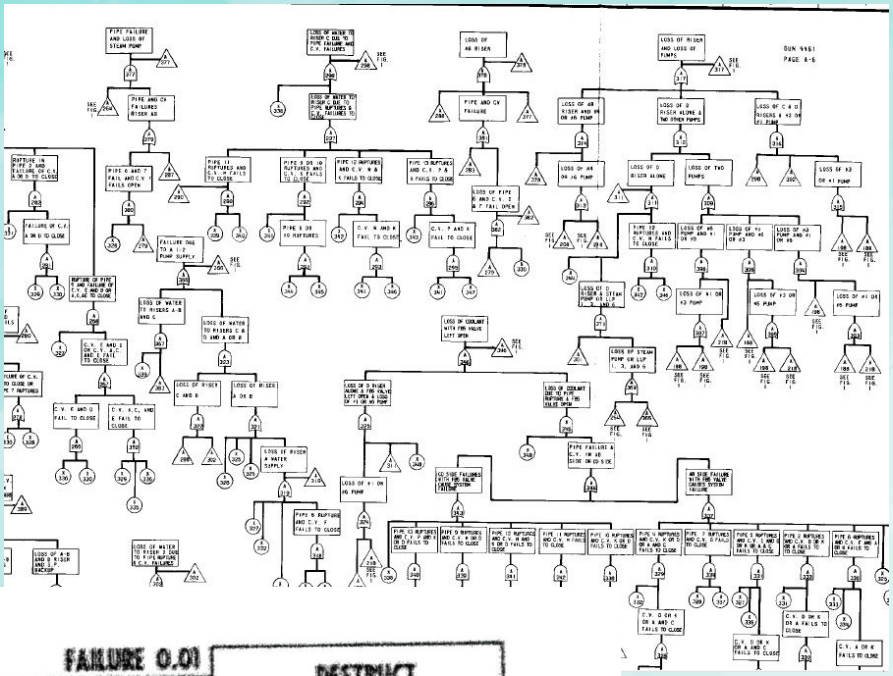
EVALUATION OF PROBABILITY OF DISASTER

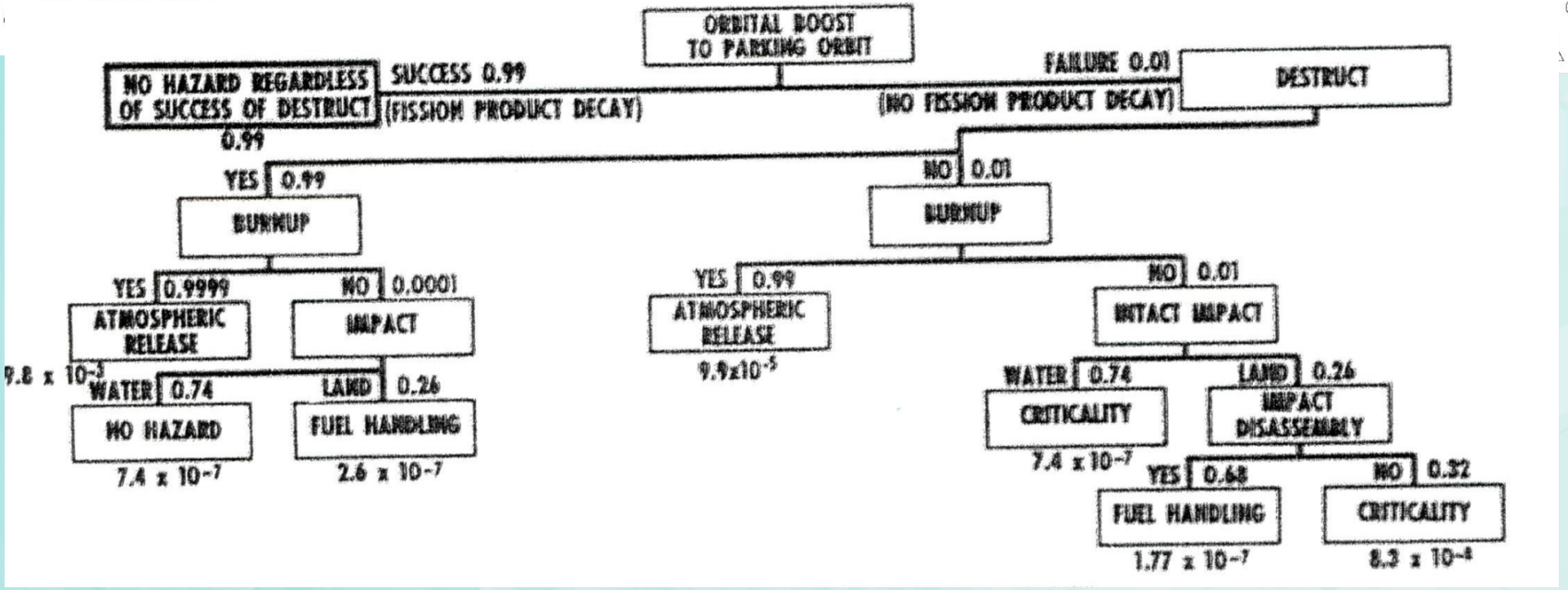
WASH-1400 and the Roots of PRA

- Methodology: Models and Goals in the 1960s
- Regulatory Necessity
- Political Necessity

Accident Modeling in the 1960s







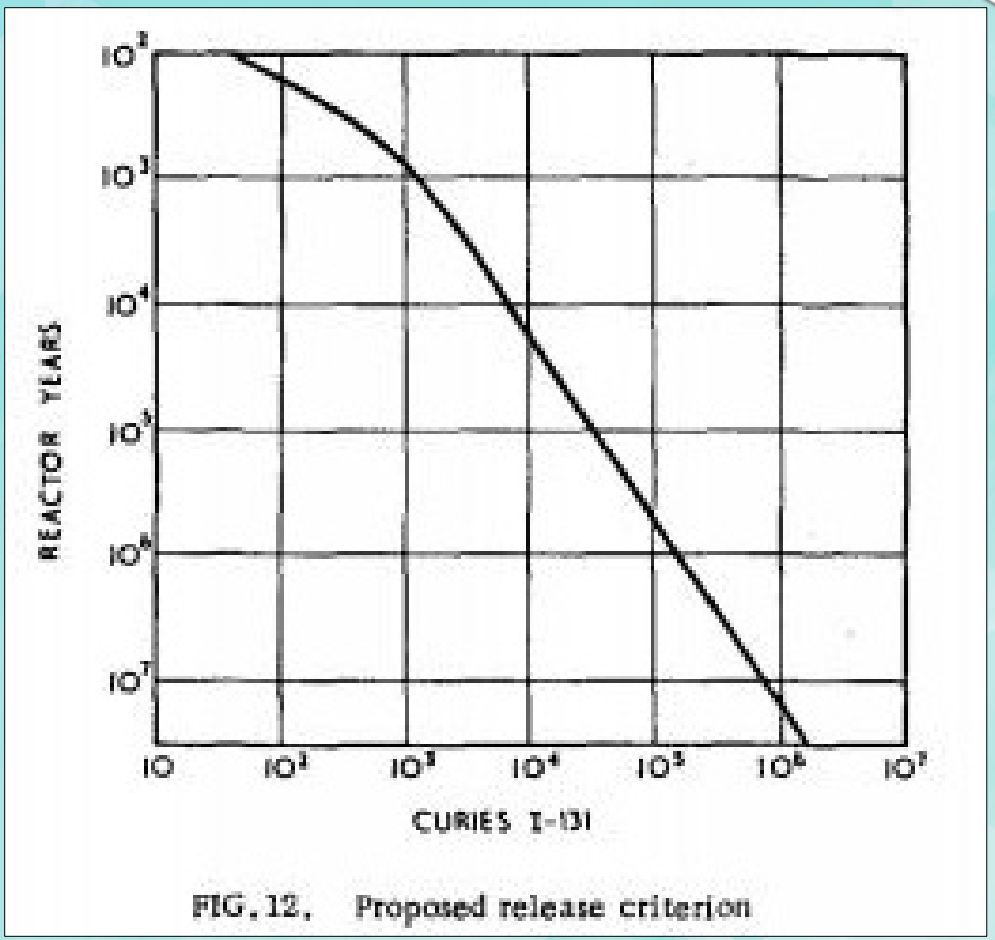


FIG. 12. Proposed release criterion

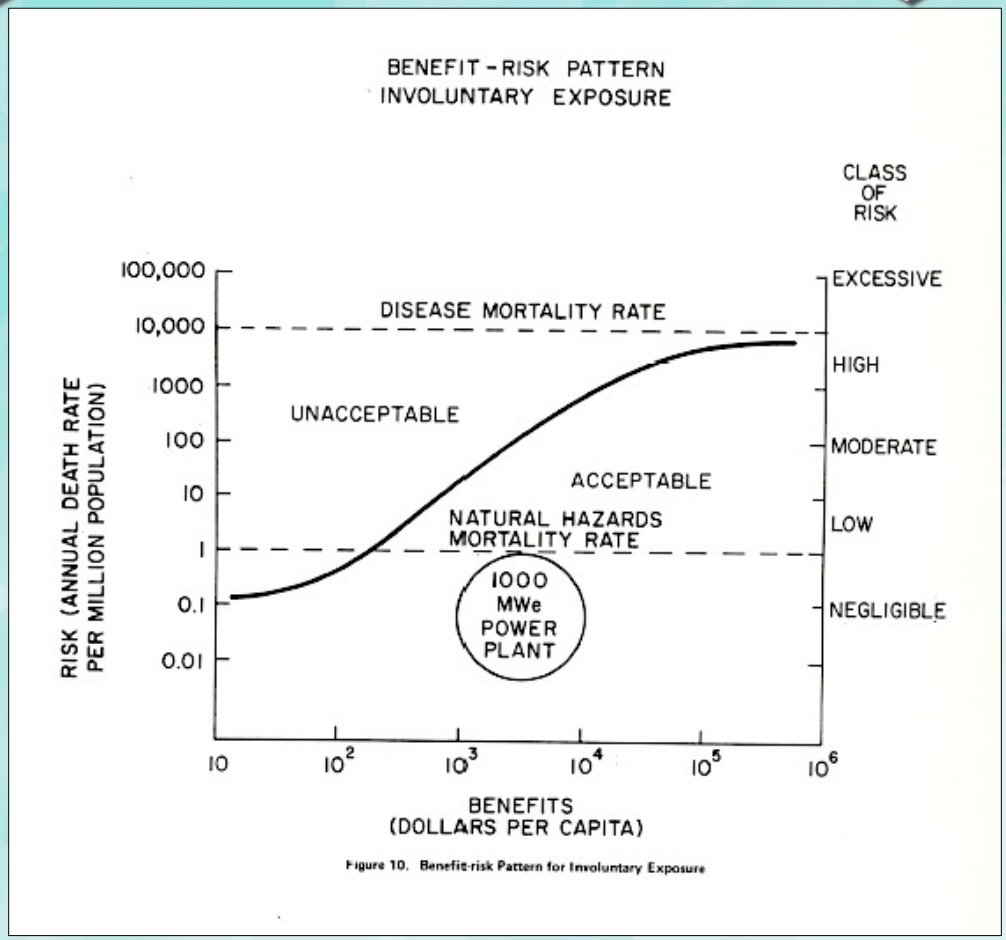


Figure 10. Benefit-risk Pattern for Involuntary Exposure

Farmer Curve

Chauncey Starr

New Safety Issues

- Loss of Coolant and the China Syndrome
  - ECCS
- Anticipated Transient Without Scram
  - Beyond the Design Basis Accident
  - Need for regulatory risk expertise

AEC Under Siege

- Anti-nuclear Movement
- Environmental Protection Agency
  - Class 9 accidents.
  - Growing interest in risk
- Congress

Henry Kendall, UCS

WASH-1400: Positives

- New tool for regulators
- A spectrum of accidents
- Core damage more likely but lower consequences

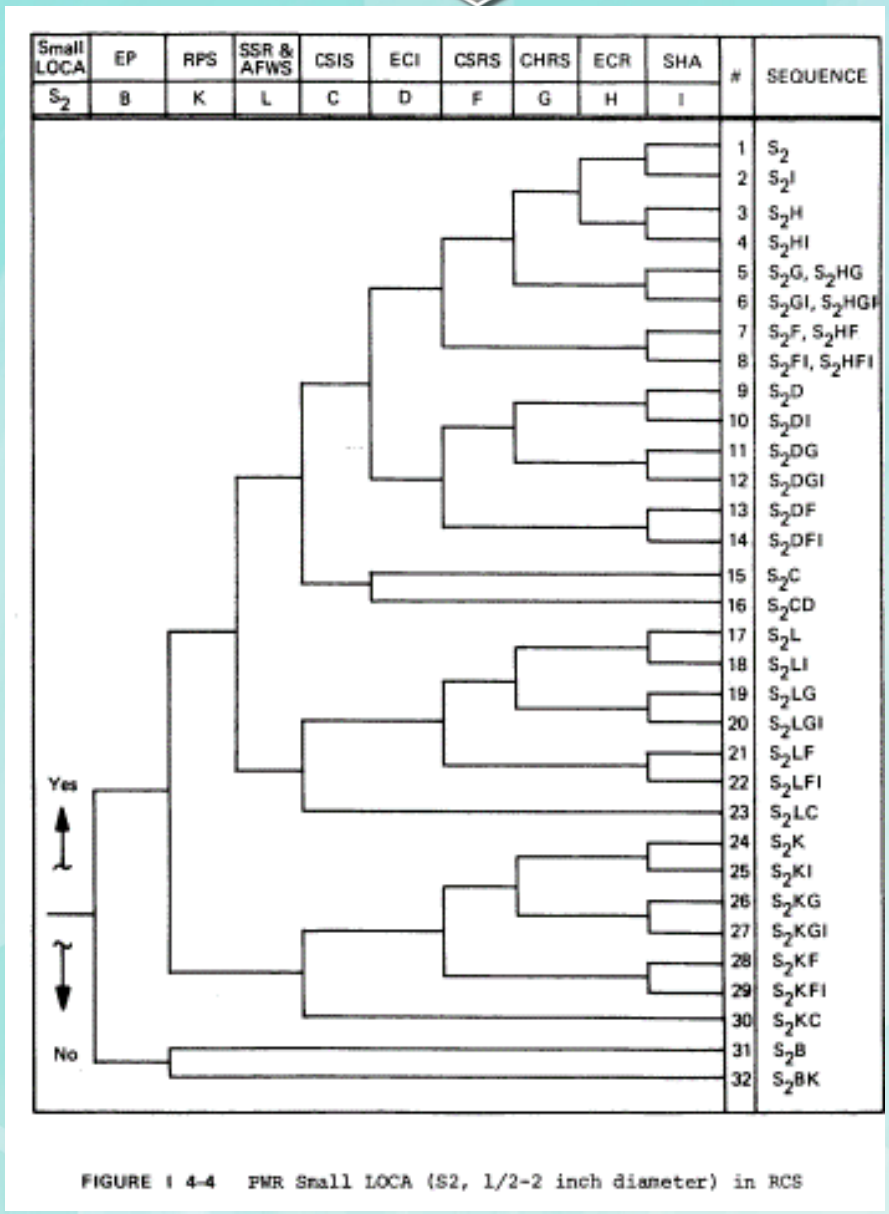


FIGURE I 4-4 PWR Small LOCA (S2, 1/2-2 inch diameter) in RCS

Small LOCA Event Tree from WASH-1400

WASH-1400: Negatives

- Large error bands
- Inappropriate comparisons to other risks
- Some accidents not analyzed
- Lacked adequate peer review
- Lewis Committee (1978)

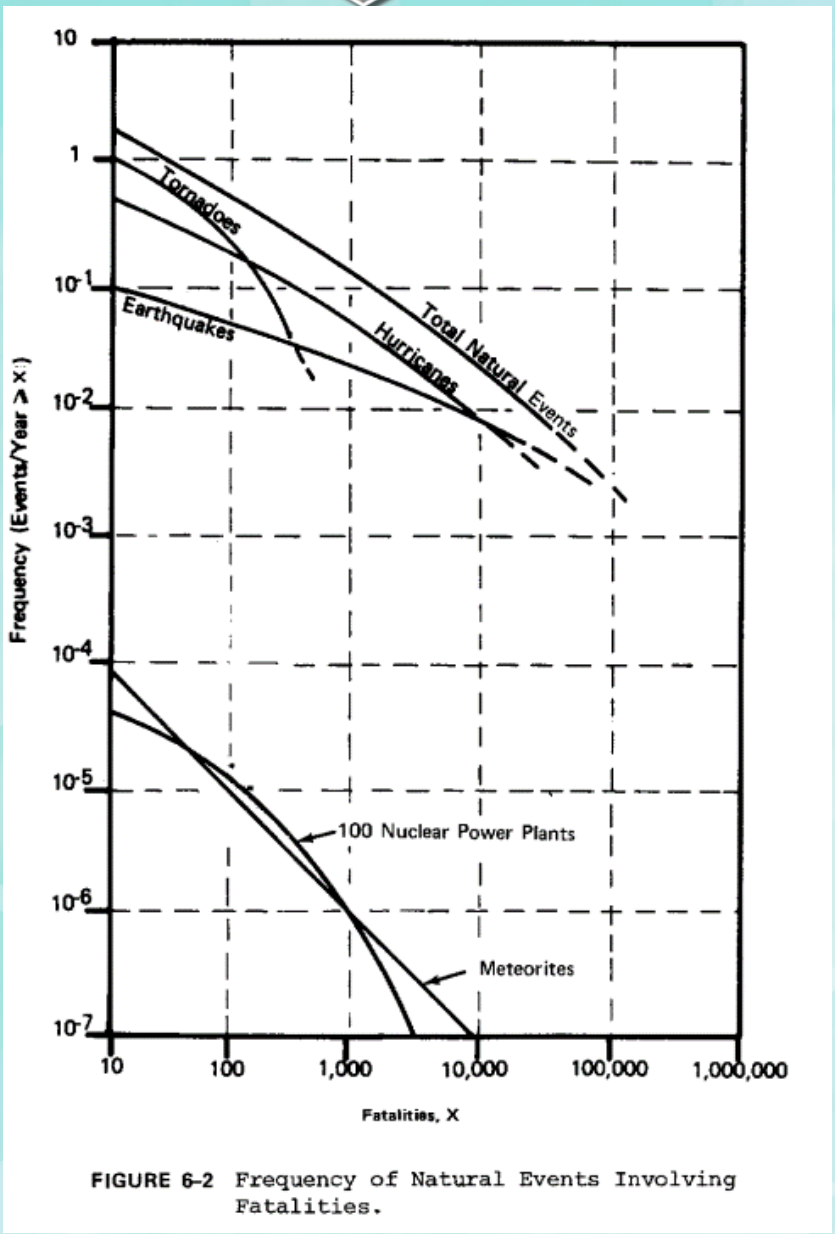
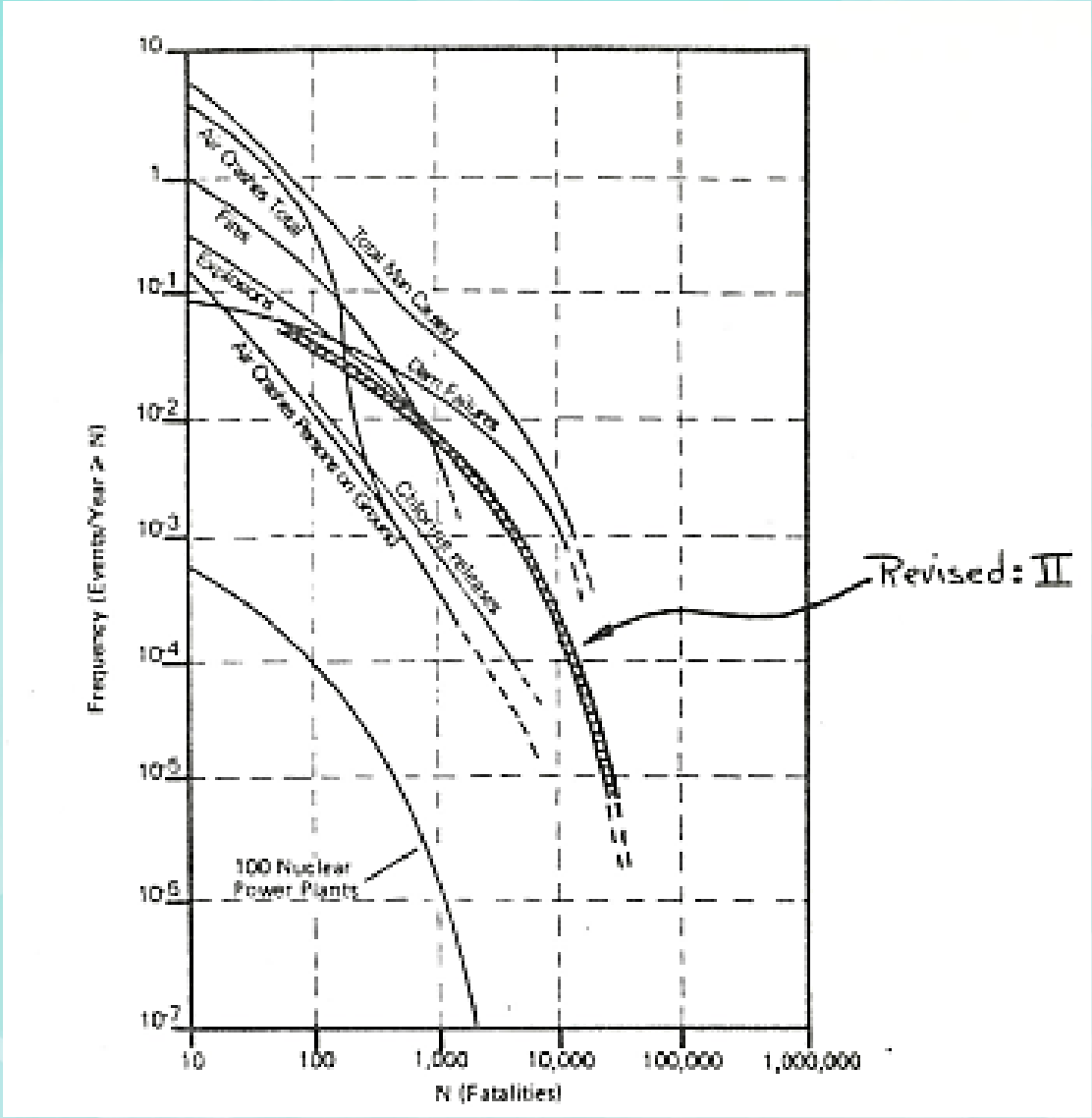


FIGURE 6-2 Frequency of Natural Events Involving Fatalities.

WASH-1400, Executive Summary



UCS Critique of WASH-1400

Three Mile Island and WASH-1400

- Human factors and operations
- Severe accidents
- Safety systems other than ECCS

TMI Control Room, March 1979

1980s: Beneficially Unfocused

- **Beyond the Design Basis**: ATWS, SBO, severe accidents
- **Unresolved Questions**: Generic issues, older plants
- **Operating Reactors**: Evaluating events
- **New Reactors**: Design certification
- **Methodology**: Industry PRAs and NUREG-1150
- **Goals:** Safety Goal Policy and Backfits

Toward Risk-Informed Regulation, 1990s

- Individual Plant Examinations
- Towers-Perrin Report
- Maintenance Rule
- PRA Policy Statement (1995) and Implementation Plan (1994)

References

- Slide 2: U.S. NRC, "An Evening with Dr. Shirley Ann Jackson," November 15, 1995, U.S. NRC ADAMS Main Library, ML003710152.
- Slide 4: C.A. Bennett to A.B. Greninger, "Evaluation of Probability of Disasters, HW-28767," July 20, 1953, DOE Public Reading Room Catalog, Accession # D8451637.
- Slide 6: P.A. Crosetti and R.F. Furrer, "Comparative Reliability Analysis—K-Reactor Secondary Coolant System, DUN-4461" (Hanford, WA: Douglas United Nuclear, September 9, 1968), U.S. Department of Energy Opennet,,https://www.osti.gov/opennet/detail.jsp?osti-id=16413875; B.J. Garrick, *Reliability Analysis of Nuclear Power Plant Protective Systems, HN-190*, May 1967, (Los Angeles: Holmes & Narver, May 1967); R.S. Hart and W.T. Harper, *Final SNAPSHOT Safeguard Report, NAA-SR-10022(Rev.)* (San Diego, CA: Atomics International, March 20, 1965).
- Slide 7: F.R. Farmer, "Siting Criteria—A New Approach," *Containment and Siting of Nuclear Power Plants, Proceedings of a Symposium, Vienna 3-7 April 1967 (Vienna: International Atomic Energy Agency, 1976)* 322; Chauncey Starr, "Social Benefit vs. Technological Risk," *Science* 165 no. 3899, September 19, 1969, 1232-38.

References (cont.)

- Slide 9: Archive of the Norfolk Charitable Trust, Sharon, MA.
- Slides 11 and 13: U.S. NRC, *Reactor Safety Study: An Assessment of Accident Risks in U.S. Commerical Nuclear Power Plants, WASH-1400 (NUREG-75/014)* (DC: U.S. NRC, October 1975).
- Slide 14: Sierra Club and Union of Concerned Scientists, *Preliminary Review of the AEC Reactor Safety Study* (San Francisco-Cambridge, December 1974), 100B.
- Slide 15: "TMI Control Room in 1979," U.S. NRC Flickr, https://www.flickr.com/photos/nrcgov/7447591188/in/album-72157628998200797/.

Acronyms

- ATWS: Anticipated Transient Without Scram
- ECCS: Emergency Core Cooling System
- PRA: Probabilistic Risk Assessment
- SBO: Station Blackout
- UCS: Union of Concerned Scientists
- WASH: AEC Headquarters, Washington, DC