Performance Based Requirements Filtering Strategies Rulemaking

June 26, 2013

BACKGROUND ON
U.S. NRC SAFETY GOAL POLICY

USNRC Safety Goal Policy Statement

- Following the accident at TMI, the USNRC was challenged to define

  "how safe is safe enough?"
- In August 1986, the Commission issued a Safety Goal Policy Statement (51 FR 30028)
- Objective of Policy:
  - "Establish goals that broadly define an acceptable level of radiological risk"
- Goals are both qualitative and quantitative

Qualitative Safety Goal

- Individual members of the public should be provided a level of protection from the consequences of nuclear power plant operation such that individuals bear no significant additional risk to life and health.

- Societal risks to life and health from nuclear power plant operation should be comparable to or less than the risks of generating electricity by viable competing technologies and should not be a significant addition to other societal risks

Quantitative Health Objectives (QHOs)

Latent Cancer Risks

The risk to the population in the area near a nuclear power plant of cancer fatalities that might result from nuclear power plant operation should not exceed one-tenth of one percent (0.1%) of the sum of cancer fatality risks resulting from all other causes.

0.1% translates to an individual latent cancer goal of

~2×10^{-6}/yr

Prompt Fatality Risks

The risk to an average individual in the vicinity of a nuclear power plant of prompt fatalities that might result from reactor accidents should not exceed one-tenth of one percent (0.1%) of the sum of prompt fatality risks resulting from other accidents to which members of the U.S. population are generally exposed.

0.1% translates to an individual early fatality goal of

~5×10^{-7}/yr

Practical Implementation of QHOs

Latent Cancer Risks

The risk to the population in the area near a nuclear power plant of cancer fatalities that might result from nuclear power plant operation should not exceed one-tenth of one percent (0.1%) of the sum of cancer fatality risks resulting from all other causes.

Requires significant quantities of fission products capable being released, i.e., core damage

Subsidiary Objective:
Total Plant CDF < 10^{-4}/reactor-year

Prompt Fatality Risks

The risk to an average individual in the vicinity of a nuclear power plant of prompt fatalities that might result from reactor accidents should not exceed one-tenth of one percent (0.1%) of the sum of prompt fatality risks resulting from other accidents to which members of the U.S. population are generally exposed.

Requires release of significant quantities of fission products before emergency protective actions, i.e., Large early release

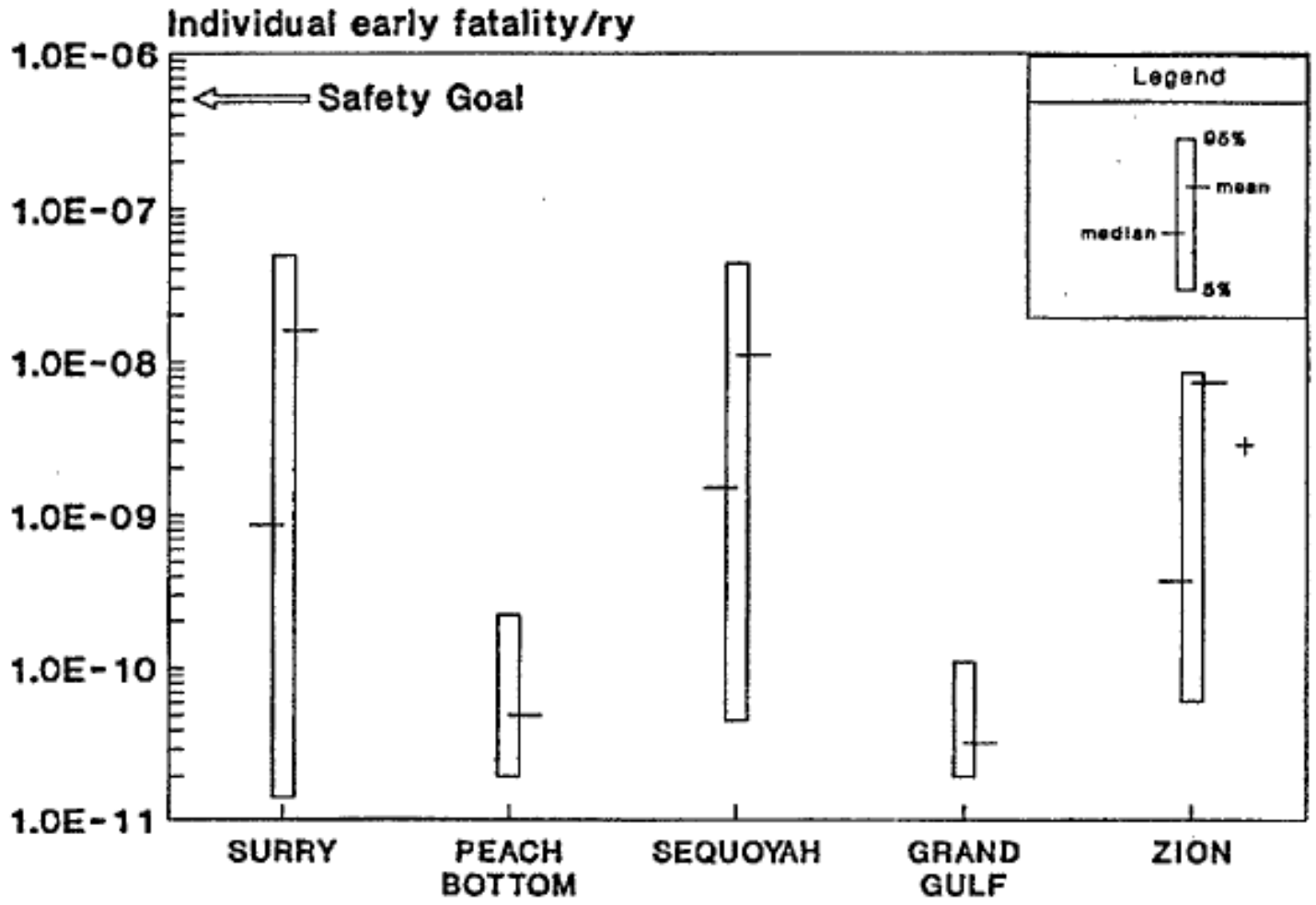
Subsidiary Objective:
Total Plant LERF < 10^{-5}/reactor-year

Calculation of Risks

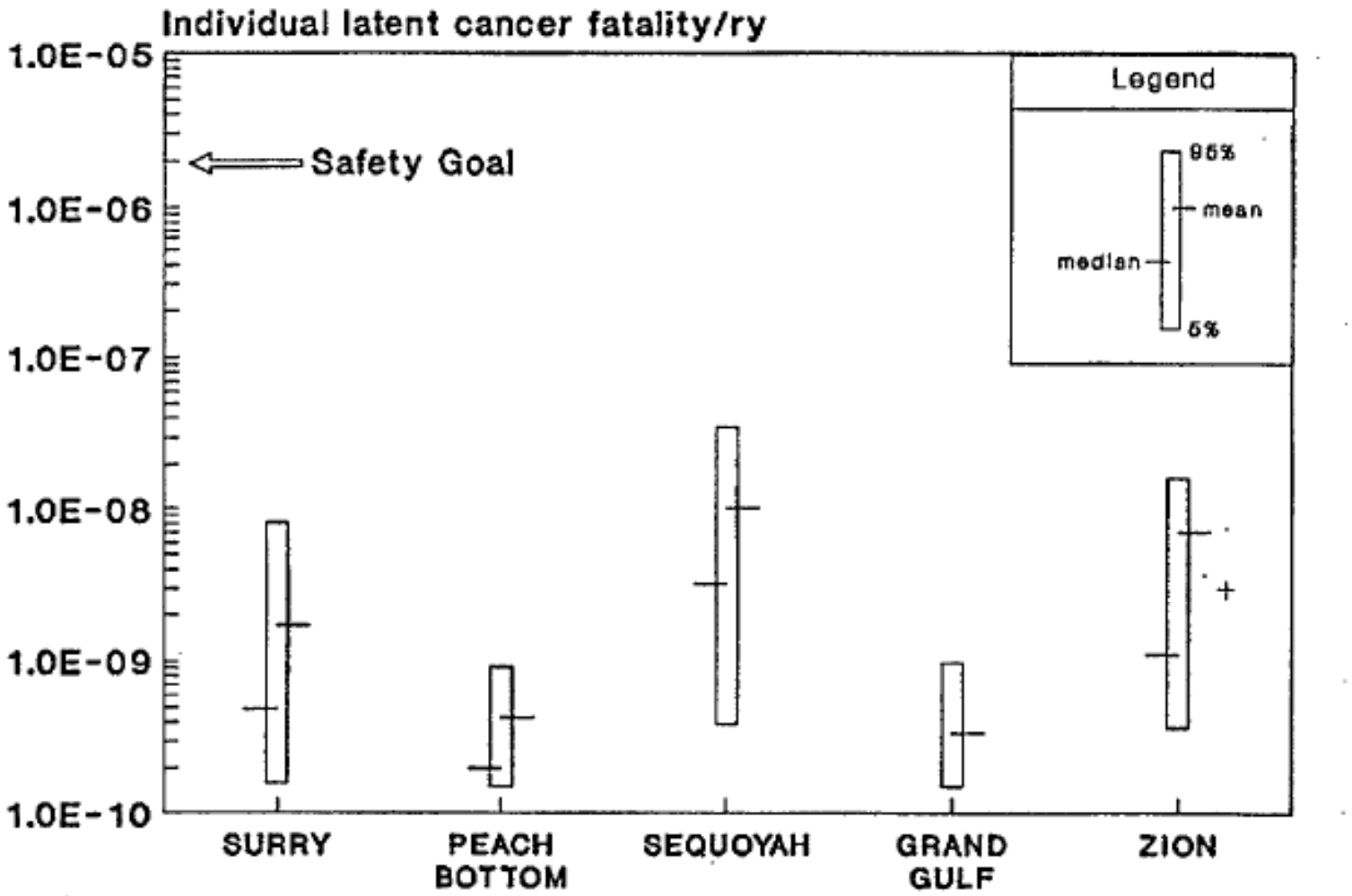
- Level 2 PRA results provide frequencies for release scenarios
  - PRA model computes the frequency
  - MAAP/MELCOR computes the source term
- MACCS2 computes conditional risk metrics for each source term
- Product of scenario frequency and conditional risk is the risk to the individual
- Sum of all scenario risks can be compared to the QHOs

$$Total\ Risk = \sum_{i=1}^{n} Frequency_{Scenario(i)} * Conditional\ Risk_{Scenario\ (i)}$$

Prompt Fatality Risks from NUREG-1150



Latent Cancer Risks from NUREG-1150



MORE RECENT RESULTS (SOARCA & SECY 12-0157)

Consideration of More Recent Analyses

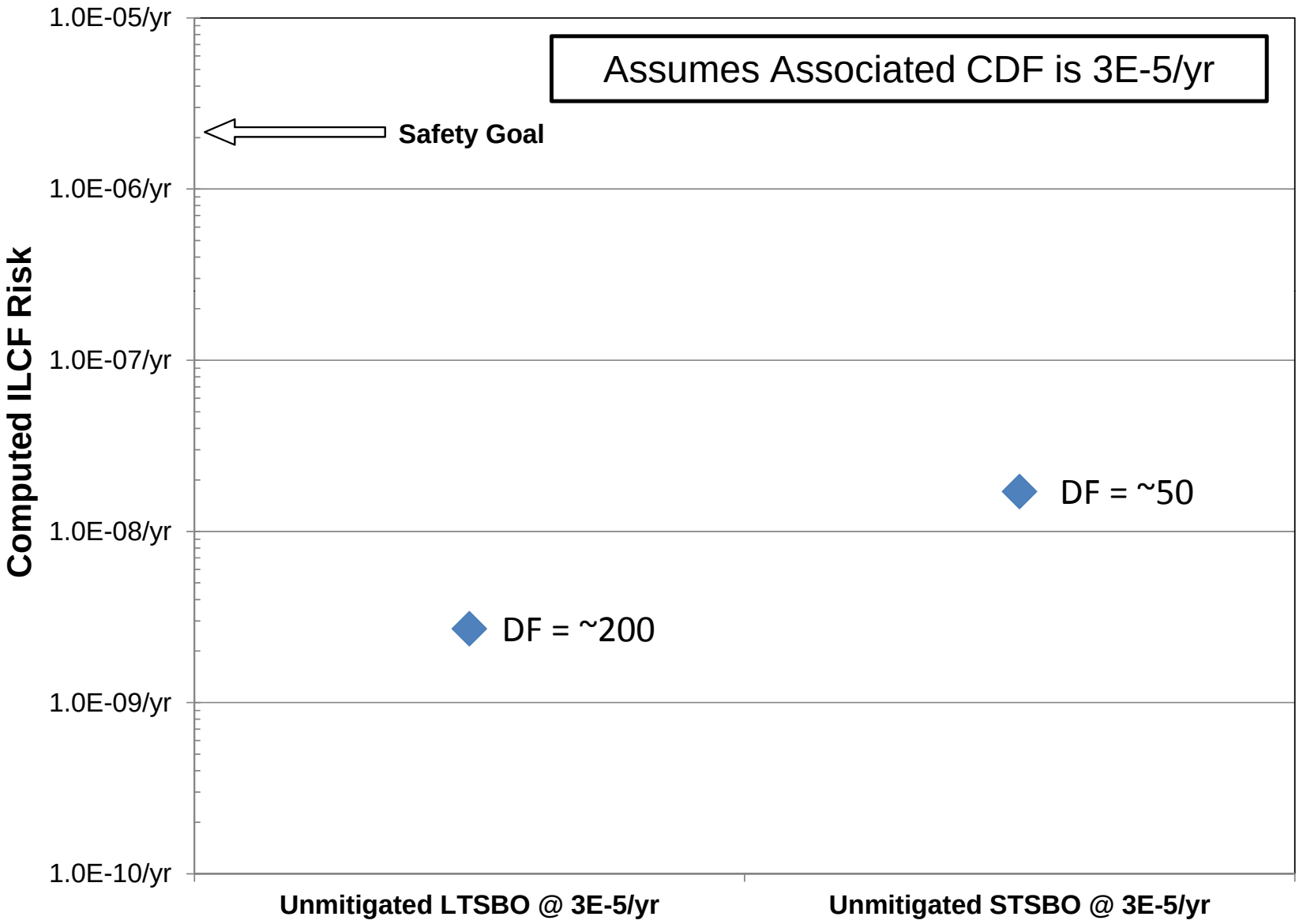
- Both NUREG/CR-7110 (SOARCA) and SECY 12-0157 evaluated conditional risks of a spectrum of BWR Mark I scenarios:
  - Prompt fatalities
  - Latent cancers
- The total risks are compared to the QHO by assuming the CDF postulated in SECY 12-0157 (3E-5/yr) applies to all scenarios:

$$Total\ Risk\ = 3E-5/yr * Conditional\ Risk$$

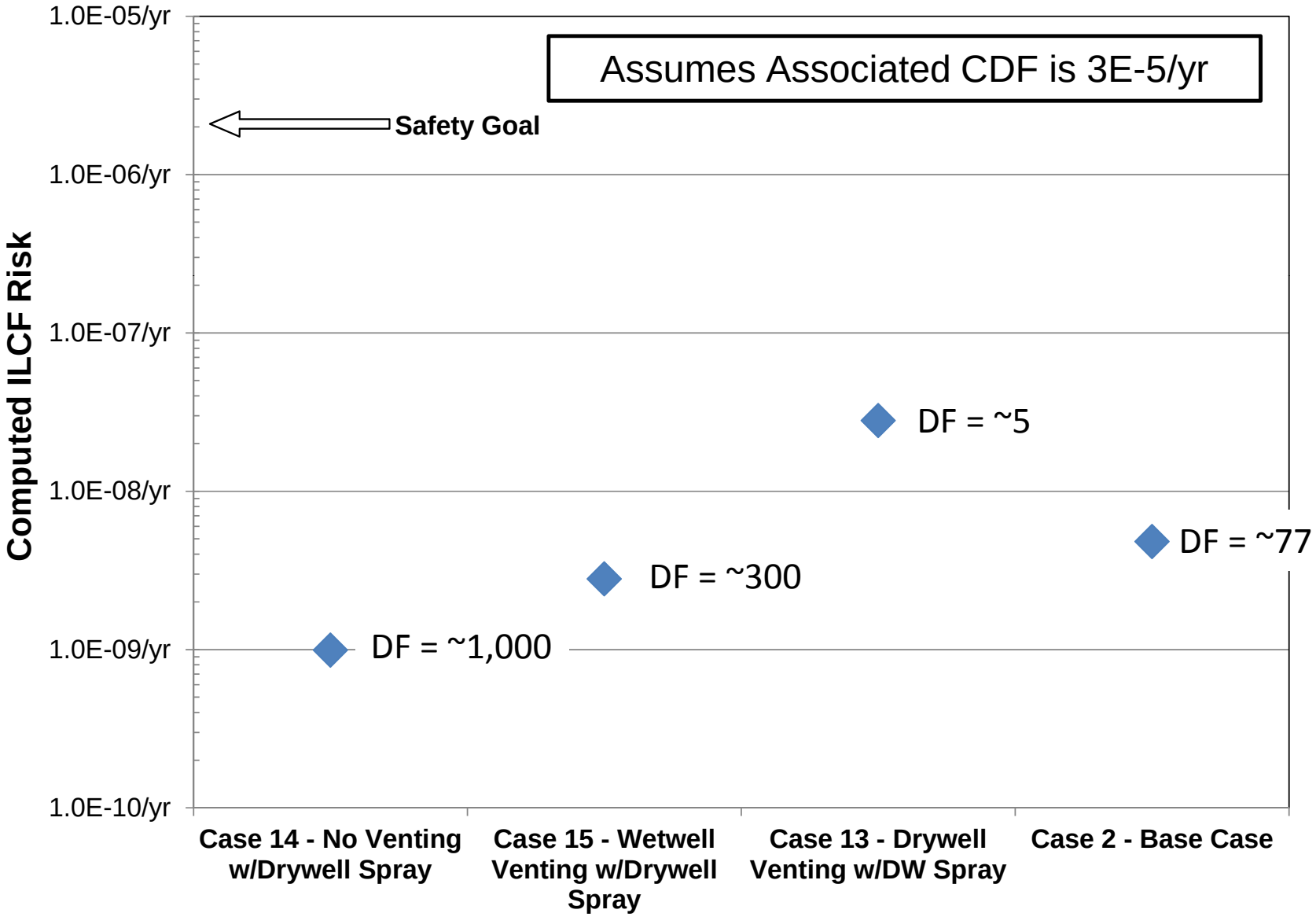
Prompt Fatality Risks

- Both SOARCA and SECY 12-0157 found that the conditional prompt fatality risk was negligible for station blackout scenarios at BWRs with Mark I containments
  - SOARCA: “prompt fatality risks are zero”
  - SECY: “prompt fatality risk are zero” except one drywell venting where the prompt fatality risks were considered “essentially zero”
- Conclusion:
  - Prompt fatalities not a consideration as a success criterion

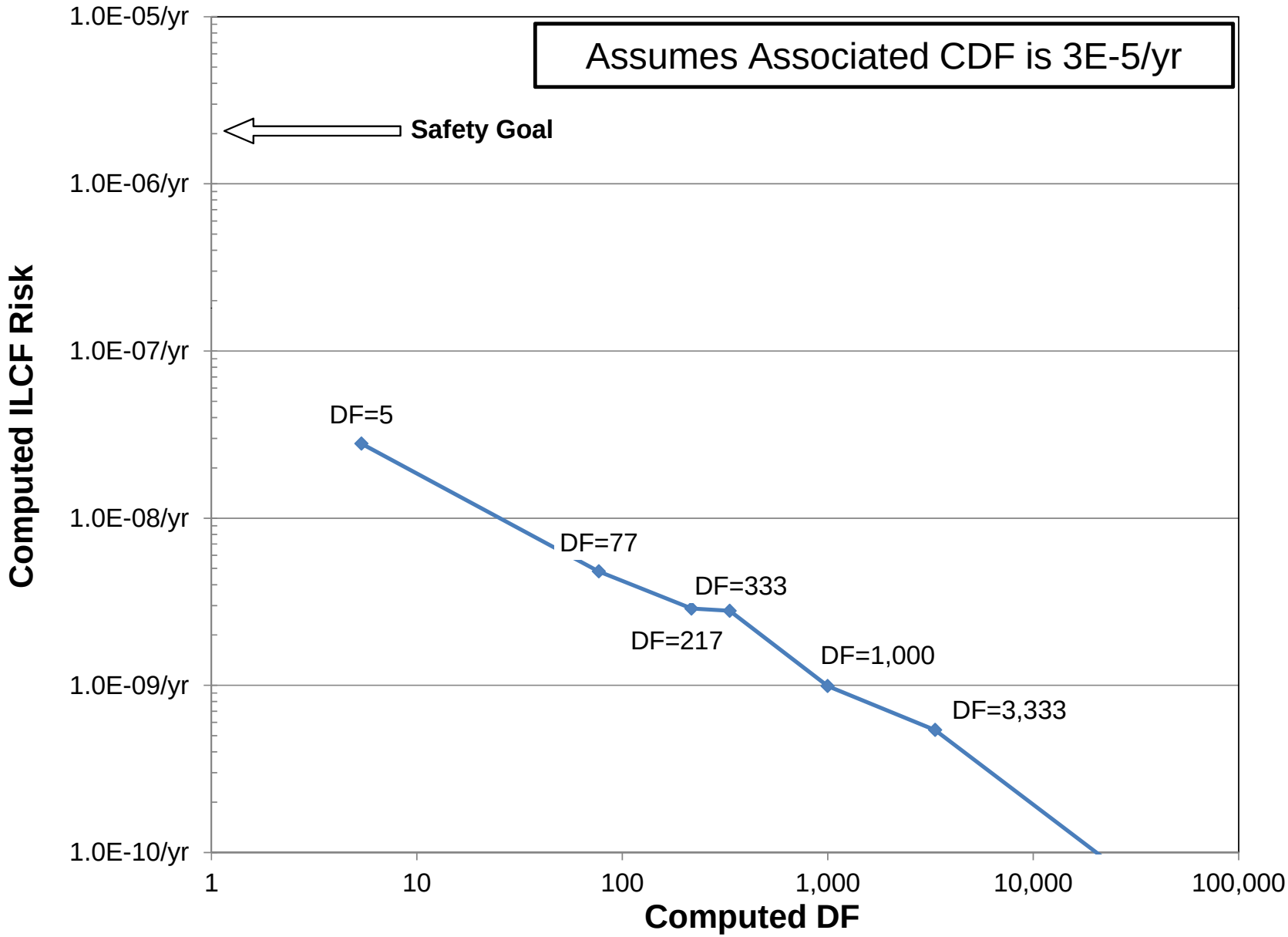
Modified SOARCA Results



SECY 12-0157 Results



SECY 12-0157 Results (DF vs. ILCF)

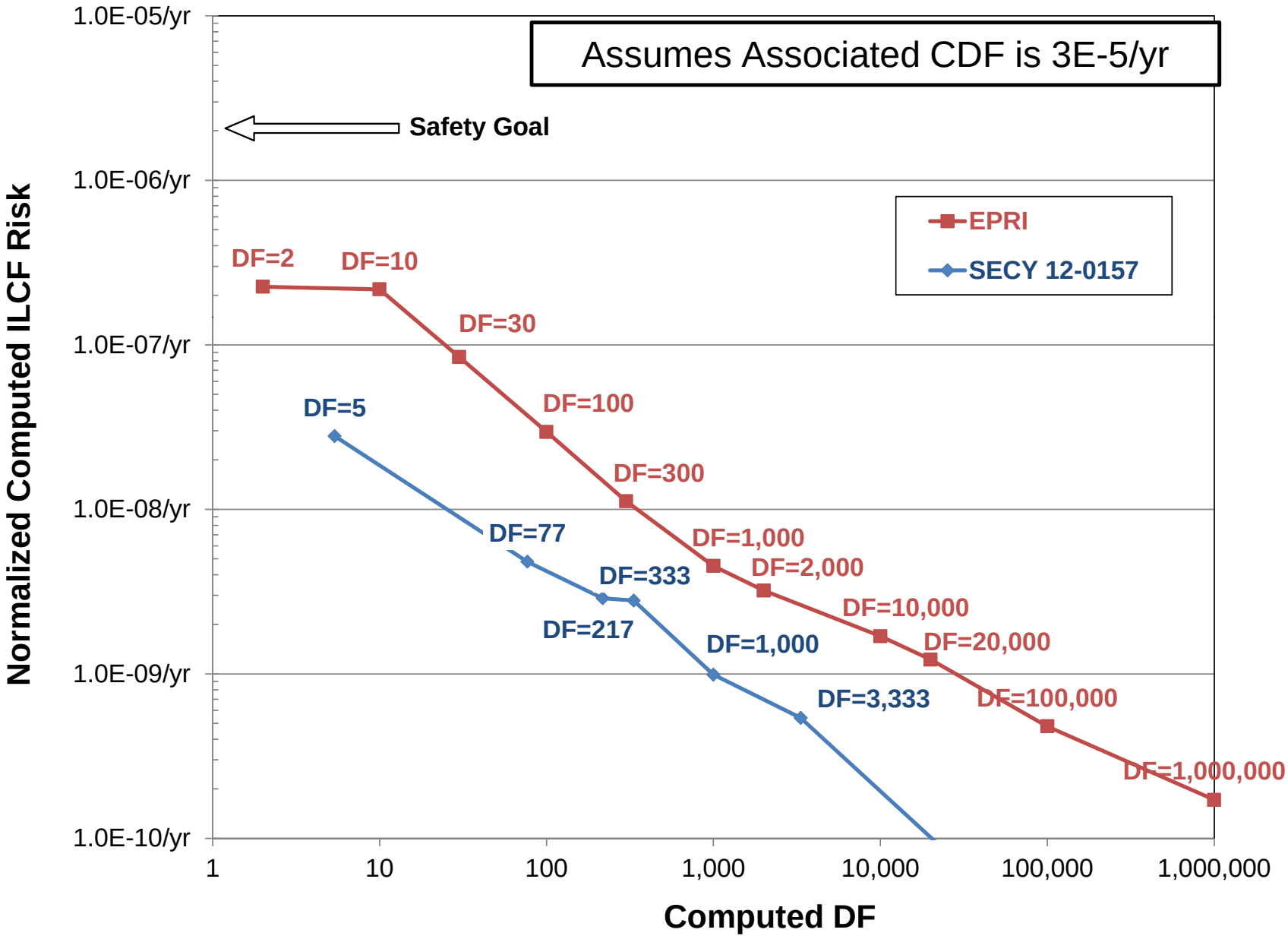


COMPARISON TO EPRI RESULTS

Background

- Both SOARCA and SECY 12-0157 used Peach Bottom as the reference site
- The MACCS2 analysis provided Appendix A of the EPRI work used a different reference site
  - Site with significantly higher population
  - Done to maximize consequences
- A comparison is made between the SECY 12-0157 results and the EPRI analysis to assess whether the insights are similar

Comparison of SECY & EPRI Results



OVERALL INSIGHTS AND CONCLUSIONS

Safety Goal Insights

- The NRC Safety Goal Policy Statement was intended to answer the question"

  "*how safe is safe enough?*"

- For the purposes of this severe accident rulemaking, focus could be on latent cancer risks
  - No potential for early fatalities
- All NRC reference plant analyses demonstrate significant margins between computed risks and QHOs
- Comparison of EPRI/SECY DF vs. QHO results indicate some plant-specific/scenario variability may exist
- DF > 100 provides a *di minimus* benefit to public health and safety

Rulemaking Focus

- Existing generic individual latent cancer fatality (ILCF) risk analysis can be used to support success criteria development.
- State of the art analyses demonstrate that there is significant margin to the ILCF QHO even when containment DF is somewhat > 100
- This inherent margin conservatively accounts for analysis uncertainties and provides confidence that public health and safety will be protected
- Therefore, the focus should be on accident management.

ACCIDENT MANAGEMENT RULEMAKING

Suggested Performance Goal

- "Implement strategies to protect public health and safety by minimizing potential ~~*Prevent the*~~ *release of-significant amounts of radioactive material following the dominant severe accident sequences through filtering strategies* ~~*with dry well filtration and severe accident management*~~"
- Basis for change:
  - Emphasis on protection of public health and safety
  - Drywell filtration is a subset of filtering strategies

Suggested Performance Objectives

- "Reduce the conditional failure probability of Mark I and Mark II containments:
  - For containment failure from liner melt-through; and
  - For severe accident over-pressure/over-temperature conditions
- ~~Provide adequate decontamination of~~ Use severe accident management to minimize the potential for controlled (venting) and uncontrolled (diffuse) fission product releases
- ~~Remove heat from core debris in the reactor vessel and in the primary containment~~
- ~~Vent hydrogen from primary containment and away from onsite buildings and structures~~ "
- Basis for change:
  - Focused on the functions of accident management
  - Hydrogen control is an element – not objective – of rule

Suggested Performance Measures

- Adequate and reliable water injection into RPV and/or containment during severe accident conditions
- Reliable means to protect containment from severe accident sustained over-temperature conditions
- Reliable means to restore and maintain containment pressure (done via EA 13-109)
- Reliable means to capture radionuclides

Attributes of Reliable

- Engineering basis for capability for defined boundary conditions
- Required equipment procured, tested, and maintained in an appropriate manner
- Operator actions feasible in defined boundary conditions

Reliability of accident management functions will improve margin to the QHO