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United States General Accounting Office

Briefing Report to the Honorable George Mitchell
United States Senate

July 1986

NUCLEAR REGULATION

Financial Consequences of a Nuclear Power Plant Accident

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UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

RESOURCES, COMMUNITY, AND ECONOMIC DEVELOPMENT DIVISION

July 16, 1986

B-223582

The Honorable George Mitchell
United States Senate

Dear Senator Mitchell:

This briefing report is our initial response to your January 27, 1986, request for information on the dollar consequences, in off-site damages to persons and property, that might result from a catastrophic commercial nuclear power plant accident. You also requested our opinion on the limit, if any, that the Congress should set on liability for accident damages. At your office's request, we agreed to provide a briefing report by early July, to be followed later by a more comprehensive report. In the latter report, we will provide additional details on the methods used to estimate nuclear plant accidents and consequences, conduct additional tests of the reasonableness of key assumptions, and incorporate the results of an ongoing Nuclear Regulatory Commission (NRC) study of accident consequences. In this regard, the financial consequence estimates presented in this briefing report should be viewed as tentative and subject to refinement in our later report.

It is important to recognize that estimating the off-site financial consequences of a catastrophic nuclear power plant accident is a technically complex undertaking. Because of the complexity involved and the availability of relevant NRC studies, your office agreed to limit the scope of our work to developing estimates of the financial consequences of accidents from existing studies. We identified two NRC-sponsored studies which, taken together, were the most comprehensive and current studies of accident consequences.[1] These studies, issued in 1982, estimated both health effects and property damages for all U.S. nuclear plants in operation or under construction. The studies reported average accident consequences on the basis of a wide range of weather conditions that might occur during an accident. According to NRC officials, actual weather conditions would significantly affect the off-site consequences of an accident.

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[1] Technical Guidance for Siting Criteria Development, Sandia National Laboratories (NUREG-CR-2239), Dec. 1982 and Estimates of the Financial Consequences of Nuclear Power Reactor Accidents, Sandia National Laboratories (NUREG/CR-2723), Sept. 1982.

After identifying these studies we performed four additional steps to estimate accident financial consequences. Specifically, we

--assigned costs to the health effects using values obtained from these studies,

--confirmed the reasonableness of health effects costs by comparing them with compensation levels awarded in radiation- and asbestos-related litigation,

--confirmed the reasonableness of property cost estimates and escalated them to 1986 dollars, and

--totalled health effects and property costs.

Finally, we reviewed how the system of insurance established by the Price-Anderson Act compensated claims for personal injury and property damages resulting from the March 1979 Three Mile Island accident.

While we are not suggesting a liability limit, if any, that the Congress should establish with respect to damages from a catastrophic nuclear power plant accident, we have illustrated the relationship of our financial consequence estimates to the current limit and to limits on liability contained in two bills (S. 1225 and H.R. 3653) under consideration by the Congress. Both bills would amend and extend the Price-Anderson Act.

As agreed with your office, we did not obtain official agency comments on a draft of this briefing report; however, we did discuss its contents with representatives of NRC. We have incorporated, where appropriate, the views and comments of these representatives. As your office also agreed, we plan to provide copies of this briefing report to congressional committees with jurisdiction over Price-Anderson Act legislation, to NRC, and to others upon request. If you have any further questions on these matters, please contact Mr. Keith Fultz at (202) 275-1441.

Sincerely yours,

J. Dexter Peach
Director

Contents

ABBREVIATIONS

DOE	Department of Energy
GAO	General Accounting Office
NRC	Nuclear Regulatory Commission
PRA	Probabilistic risk analysis
TMI	Three Mile Island

HIGHLIGHTS

STATE OF KNOWLEDGE OF ACCIDENT CONSEQUENCES

Estimating the financial consequences of a catastrophic nuclear plant accident cannot be done with precision. Because such an accident has never occurred at a plant of U.S. design, there is no experience from which to draw. Experts do know, however, that accidents involving irradiated fuel in the reactor core with a coincident breach of the containment structure would be a necessary step to major environmental contamination. The most severe accident (a catastrophic accident) would involve extensive core damage, failure of all safety features, and a massive, early breach of the containment. The next worst accident (a severe accident) involves the same circumstances except that some safety systems work and the containment breach is not immediate. Other core-melt accidents might not involve any off-site damage if the containment systems operate as designed.

Probabilistic risk analysis is considered the best tool available for analyzing potential accidents. This type of analysis identifies the types of accidents that can have an impact off-site and estimates the probability that they will occur as well as their likely consequences. NRC first applied these techniques to nuclear power plants in its 1975 Reactor Safety Study. Although criticized for its selection of assumptions, the study was generally praised as being the best analysis of accidents available at that time. Its general methodology has formed the basis for all subsequent analyses of reactor safety.

NRC has subsequently performed many other studies that have built upon additional nuclear power plant experience and improved risk assessment techniques. Two NRC-sponsored studies--Technical Guidance for Siting Criteria Development (NUREG/CR-2239), issued in December 1982, and Estimates of the Financial Consequences of Nuclear Power Reactor Accidents (NUREG/CR-2723), issued in September 1982--taken together are the most current assessment of nuclear plant accident consequences. Using the methods developed in the Reactor Safety Study, these studies calculated the health effects and the costs associated with property damages for all nuclear power plants that were then operating or under construction.

REVIEW PURPOSE AND METHODOLOGY

The purpose of our review was to assess the financial consequences to the public of a nuclear plant accident and to compare these consequences with current and proposed liability limits now being considered by the Congress in bills to amend and extend the Price-Anderson Act. The act provides a system of insurance to pay claims for personal injury and property damages resulting from a nuclear accident.

We used the 1982 NRC studies as our basis for estimating off-site health effects and property damages and assigned costs to

health effects using values recommended in these reports. We tested the reasonableness of this cost assignment by comparing it with the average compensation that courts awarded for alleged injuries and deaths in radiation- and asbestos-related litigation. Because the NRC studies contained the best estimates of property damages, we accepted the property damage costs and escalated them to 1986 dollars.

We then compared the total off-site financial consequences with the nuclear plant accident liability limit established by the Price-Anderson Act and to limits proposed in H.R. 3653 and S. 1225.

Finally, we studied the treatment of claims arising from the March 1979 Three Mile Island (TMI) accident to determine how the Price-Anderson insurance system performed for this accident.

LIMITATIONS OF STUDY

Our study has limitations resulting from the uncertainties inherent in this type of analysis and from the limited scope of our review. The uncertainties in the estimates of accident consequences derive from the scarcity of information on accident behavior, the relationships of radiation doses to health effects, and the specific weather conditions and evacuation measures that will be associated with an actual accident. Our study did not estimate the cost of investigating, settling, and defending claims, which is a related off-site cost compensable under the Price-Anderson insurance structure. We also did not address on-site costs and indirect economic losses which, while outside the scope of Price-Anderson, nevertheless represent real costs of a nuclear plant accident.

AVERAGE FINANCIAL CONSEQUENCES FOR CATASTROPHIC AND SEVERE ACCIDENTS

The NRC studies report average consequences that represent the worst accidents under typical weather conditions. According to NRC officials in the Office of Nuclear Regulatory Research, under the most severe weather conditions, which are estimated to be 100 to 1,000 times less likely to exist, these consequences could be up to approximately 10 times greater than represented here.

For the eight plants we selected for illustration purposes, the estimated average off-site accident consequences resulting from a catastrophic nuclear plant accident range from $300 million to $15 billion. In contrast, the average consequences of a severe accident would be lower, ranging from $5 million to $220 million. While these ranges are displayed for only eight plants, they encompass all 117 plants now operating or under active construction, with the exception of two to three that fall below the low end of the ranges.

CATASTROPHIC ACCIDENTS DOMINATE NUCLEAR ACCIDENT RISKS

A catastrophic accident is the accident of greatest risk as well as greatest consequence to the public. Although the probability of this type of accident occurring has been estimated to be on the order of one-half that of a severe accident, the financial consequences would be many times greater.

HOW AVERAGE CATASTROPHIC ACCIDENT CONSEQUENCES COMPARE WITH PRICE-ANDERSON LIMITS

The current limit of $665 million covers the estimated average off-site financial consequences at 5 of the 117 plants (4 percent). A catastrophic accident at any of 75 of the 117 nuclear plants (64 percent) would be covered by the $2.5 billion limit proposed in S. 1225. The $6.5 billion limit proposed in H.R. 3653 would cover 111 of the 117 plants (95 percent). It should be emphasized that these comparisons are for average consequences. As indicated earlier, according to NRC officials, the financial consequences of a catastrophic accident under severe weather conditions could be up to approximately 10 times greater than average consequences. Although very severe weather conditions are improbable, if they are considered in estimating financial consequences, even the limits proposed by the Senate and House bills might not cover the majority of the plants.

TMI-RELATED PERSONAL INJURY AND PROPERTY DAMAGE CLAIMS

TMI was neither a catastrophic nor a severe accident as defined in this report. The measured levels of radiation released during the accident were low when compared with expected releases from catastrophic or severe accidents. The only health effects claims that have been made at TMI relate to the possibility of future cancers rather than actual illnesses. Property damage claims involve compensation of economic losses for a precautionary evacuation and alleged reduction of property values. To date, approximately $41 million has been paid for TMI claims in an out-of-court settlement. However, since that settlement, 2,000 additional claims have been filed.

STATE OF KNOWLEDGE OF ACCIDENT CONSEQUENCES

ACCIDENTS THAT RESULT IN SUBSTANTIAL RADIOLOGICAL DAMAGE

- Only core-melt accidents with a coincident breach of the containment building could cause substantial off-site damage:
  - --A catastrophic accident, resulting from extensive core damage, the failure of all safety features, and a large, early breach of the containment building, would cause the greatest damage.
  - --A severe accident, where extensive core damage has occurred but some mitigating safety features operate and the containment building breach is not immediate, would result in the next worst consequences.

SECTION I

STATE OF KNOWLEDGE OF ACCIDENT CONSEQUENCES

ACCIDENTS THAT RESULT IN SUBSTANTIAL RADIOLOGICAL DAMAGE

Assessing catastrophic accident consequences is a very difficult task to do with any degree of accuracy because of limited experience with major plant accidents from which to draw. The accidents of interest in considering the adequacy of the Price-Anderson liability limit are those of such a severe nature that none have occurred in the history of the U.S. commercial nuclear power program. Although the recent accident in the Soviet Union at Chernobyl was a catastrophic accident, even with the cooperation of the Soviet Union, it will take U.S. scientists many years of study to fully understand the accident and its consequences to human health and property.

Experts do know, however, that only accidents involving irradiated fuel in the reactor core could cause substantial radiological damage to the environment. A core-melt accident with a coincident breach of the containment structure would be a necessary step to major environmental contamination. The most severe accident, defined here as a catastrophic accident, would involve extensive core damage, the joint or sequential failure of all safety features, and a massive, early breach of the containment. The next worst accident, called a severe accident in this report, involves the same circumstances with the exception that some safety systems continue to operate, and the containment breach is not immediate. Other core-melt accidents might not involve any off-site damage if the containment systems operate as designed.

PROBABILISTIC RISK ANALYSIS IS THE BEST TOOL FOR ESTIMATING ACCIDENT DAMAGES

- o PRA is recognized as the best tool for estimating nuclear accident damages.
- o PRA provides a logical framework for examining complex technical systems to identify and measure health, environmental, and economic risks of nuclear plants.

Components of PRA	Areas of uncertainty
o On-site:	
--Analysis of accidents that result in core melting	o Data on equipment failure and human error
	o Handling dependent failures
	o Modeling all possible failures
--Analysis of behavior of radioactive materials within the containment building and their release	o Understanding the chemical/physical behavior of radioactive materials
	o Modeling the response of containment safety systems
o Offsite:	
--Analysis of the transport of radioactive materials off-site and their effects on health and property	o Weather conditions at the time of the accident
	o Modeling dispersion of radioactive materials in various weather conditions
	o Emergency response to the accident
	o Understanding the relationship between dose and health effects

PROBABILISTIC RISK ANALYSIS IS THE BEST TOOL FOR ESTIMATING ACCIDENT DAMAGES

Even though no accidents have occurred in the United States in which the public has been exposed to large amounts of radioactive materials, NRC analyzes potential catastrophic accidents for regulatory purposes. NRC has developed probabilistic risk analysis (PRA) techniques for estimating the probability of such accidents occurring and their likely consequences. PRA permits analysts to systematically examine complex technical systems to identify and measure the public health, environmental, and economic risks of nuclear plants. Thus, PRA provides a logical and disciplined framework for analyzing potential accidents, and thus, according to two groups that investigated the TMI accident, PRA is the best available guide to identifying important accidents.

PRA studies consist of three distinct parts. First, a wide variety of accident sequences are identified and developed, including those that could lead to fuel melting and the subsequent release of radioactive materials from the reactor core into the surrounding containment building. Second, the ability of safety systems and the containment building to prevent these materials from being released into the environment is analyzed. Finally, the movement of radioactive material is modeled as it is transported from its release point at the reactor containment building to off-site areas, and off-site radiation doses and contamination levels are then calculated. This type of analysis generates the following measures of off-site consequences: (1) early health effects, (2) late health effects, and (3) property damages (i.e., economic losses or amount of land contaminated).

Uncertainties are associated with virtually every stage of a PRA. For example, only limited data are available concerning the likelihood of equipment failure and human error, which are both important in estimating the probability that a catastrophic or severe accident could occur. Whether all possible failures have been modeled is another uncertainty. In addition, the physical and chemical behavior of radioactive material within the containment building after being released from the core is not fully understood, and the modeling in this area is based on incomplete information. Sources of uncertainty in calculating off-site effects are the particular weather condition at the time of the accident, the dispersion of radioactive materials, emergency response to the accident, and the relationship between dose and health effects. As a result of these uncertainties, many assumptions must be made throughout the analysis. In general, the assumptions are chosen conservatively so that the consequences to the public are not underestimated. However, using the most conservative weather assumptions would imply larger consequences than would realistically be expected. PRAs usually handle these

uncertainties by repeating the calculation of off-site consequences for a wide range of weather patterns. A more detailed discussion of PRA can be found in our earlier report, Probabilistic Risk Assessment: An Emerging Aid to Nuclear Power Plant Safety Regulation (GAO/RCED-85-11, June 19, 1985).

OVERVIEW OF NRC CONSEQUENCE ANALYSES

Date	NRC Study	Scope	Features
1975	o Reactor Safety Study	o 100 plants at 6 composite sites	o First comprehensive and quantitative analysis of accident sequences o Good perspective on risk o Monetized property damages
1982	o Technical Guidance for Siting Criteria Development o Estimates of the Financial Consequences of Nuclear Power Plant Accidents	o 156 plants at 91 sites	o Improved consequence model o Calculated consequences at each reactor site o Monetized health effects and property damages
1986	o NUREG 1150 (to be issued in draft 9/86)	o 6 plants at 6 sites	o Improved estimates of amount of radiation released o Improved consequence model

OVERVIEW OF NRC CONSEQUENCE ANALYSES

NRC first applied PRA techniques to nuclear power plants in its 1975 Reactor Safety Study.[1] That study was a comprehensive assessment of a wide variety of potential accidents for two types of reactors at six composite sites that incorporated population distribution features and meteorological conditions from 100 plants. The Reactor Safety Study was criticized for using overly conservative assumptions in some areas and nonconservative ones in others. However, it was generally praised as being the best analysis of accident consequences available at that time. Its general methodology has formed the basis for all subsequent analyses of reactor safety. After the March 1979 TMI accident, for example, a presidential commission investigating the accident recommended that NRC use PRA techniques in safety analyses. PRA, they said, was the best available tool for identifying how serious accidents could occur and predicting their consequences. Since TMI, NRC has continued to develop and apply its PRA-based analytical techniques.

NRC has subsequently performed many PRAs that have built upon additional nuclear plant experience and improved risk assessment techniques. At present, two NRC-sponsored studies, Technical Guidance for Siting Criteria Development (NUREG/CR-2239), Dec. 1982, and Estimates of the Financial Consequences of Nuclear Power Reactor Accidents (NUREG/CR-2723), Sept. 1982, taken together, are the most comprehensive and current studies of estimated accident consequences. These studies estimated early injuries, early fatalities, and latent cancers for all 156 U.S. plants then either in operation or under construction and applied dollar values to health effects and property damages using the methods developed in the Reactor Safety Study. Property damage costs include lost wages, relocation expenses of the evacuated population, decontamination costs, lost public and private property costs, and interdicted land and farm crop values.

Since these studies were issued in 1982, new information has become available that might affect the calculation of off-site consequences. In particular, the accident at TMI indicated that less radioactive material might escape the containment building than previously assumed. NRC is currently performing a detailed analysis of six selected reactors, incorporating this new information and updating the consequence models used in the Reactor Safety Study. An initial draft of these results is expected to be published in September 1986.

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[1] Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants, Nuclear Regulatory Commission (NUREG-75/014), Oct. 1975.

REVIEW PURPOSE AND METHODOLOGY

PURPOSE

- We were requested to:
  - --Assess the health effects and property damage costs that might result from a nuclear plant accident.
  - --Render an opinion on the limit, if any, on liability that should be set under the Price-Anderson Act.
- Congress is considering Price-Anderson legislation that would change the liability limit.

SECTION II

REVIEW PURPOSE AND METHODOLOGY

PURPOSE

On January 27, 1986, Senator George Mitchell, a member of the Senate Committee on Environment and Public Works, requested that we conduct a study of the dollar consequences, in off-site damages to persons and property, that might result from a catastrophic nuclear accident. He also requested that we render an opinion on the limit, if any, on nuclear accident liability that should be set under the Price-Anderson Act.

The Price-Anderson Act, enacted into law in 1957 as an amendment to the Atomic Energy Act of 1954, provides a system of private insurance and government indemnification (reimbursement) to pay funds for claims of the public for personal injury and property damage resulting from accidents involving commercial nuclear power plants, Department of Energy (DOE) contractors, and licensed facilities used for research and development purposes. It also limits liability for accidents at commercial nuclear power plants to $5 million per operating plant plus $160 million in insurance (at present a total of $665 million). Since its enactment, the Price-Anderson Act has twice been extended for successive 10-year periods. Unless the Congress acts before August 1, 1987, the authority of NRC and DOE to enter into new indemnification agreements with utilities and DOE contractors will expire. However, existing nuclear plants will continue to be covered as long as they are licensed to operate, and existing DOE contracts will be covered until they expire.

Nearly 3 decades after its enactment, controversy still surrounds the Price-Anderson Act. The heart of this controversy relates to the limitation on liability: whether there should be a limit and, if so, at what level. Bills have been introduced in both the House and Senate that propose changes to this limit. The primary ones, H.R. 3653 and S. 1225, originated from committees with Price-Anderson jurisdiction. H.R. 3653, as reported out by the House Committee on Interior and Insular Affairs, would raise the liability limit to $6.5 billion, and S. 1225, under consideration by the Senate Committees on Environment and Public Works and Energy and Natural Resources, specifies a limit of $2.5 billion.

METHODOLOGY

- Because of the complexity involved in estimating accident consequences and the availability of relevant NRC studies, we agreed to rely on the best reported data, recognizing its limitations.

- We performed six steps in our consequence analysis. We

  --selected health effects and property damage estimates from two NRC-sponsored studies issued in 1982,

  --assigned costs to the health effects using values obtained from these reports,

  --tested the reasonableness of health effects costs by comparing them with compensation levels awarded in radiation- and asbestos-related litigation,

  --escalated property costs,

  --totalled health effects and property costs, and

  --compared consequences with current and proposed Price-Anderson Act liability limits.

- We also reviewed the TMI accident to determine how the Price-Anderson insurance system performed for this accident.

METHODOLOGY

Because of the complexity involved in estimating accident consequences and the availability of relevant NRC studies, we agreed with Senator Mitchell's office to rely on the best reported data on accident consequences as the basis for our estimates, recognizing the uncertainties inherent in accident analysis.

Our audit methodology was to first identify the best available measure of accident consequences. For estimates of health effects and property damages, we relied on the mean values[2] generated in the 1982 NRC-sponsored studies. We limited our analysis to the worst two of the five types of accidents discussed in the studies because these were the only accidents with significant off-site consequences, and we refer to them here as catastrophic and severe. We also restricted the scope of our work to the 117 nuclear plants now operating or under active construction rather than consider all 156 plants, some of which have been cancelled or deferred indefinitely. We selected 8 of the 117 plants for illustration in our report. Five of the plants we selected are plants that NRC is currently using in a new study of off-site consequences--Grand Gulf, Surry, Sequoyah, Peach Bottom, and Zion. NRC's basis for selecting the plants for its study is that they represent different types of reactor and containment designs. We included two plants--Maine Yankee and Seabrook--at the request of Senator Mitchell. Finally, we included the Indian Point plant, located north of New York City, because it is located at one of the most densely populated plant sites, and hence has the most severe off-site consequences associated with it.

Next, we assigned costs to the three health effects reported in the 1982 studies to obtain a total cost associated with health effects for each accident. These costs are difficult to select for use in analysis because they will ultimately be determined by the courts if an accident occurs. For this analysis, we used the costs suggested in the 1982 studies--$100,000 for early injuries and latent cancers and $1 million for early fatalities.

We tested the reasonableness of the assumed health effects costs by comparing them with average compensation levels awarded in radiation- and asbestos-related litigation. Specifically, we looked at the awards made in the Irene Allen vs. the United States case brought against the government for leukemia deaths and latent

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[2]The mean values in the 1982 reports represent averages of consequences for a wide variety of weather conditions prevailing at the time of the accident. Actual consequences could be less severe or more severe, depending on the particular weather at that time.

cancers resulting from nuclear fallout from atmospheric nuclear weapons testing in Nevada during the 1950's. We also looked at average compensation for asbestos-induced injuries and cancers for claims against asbestos manufacturers that had been closed between January 1980 and August 1982, as reported in a 1984 Rand Corporation study, Variation in Asbestos Litigation Compensation and Expenses. This comparison is summarized below:

TABLE II.1:
COMPARISON OF NRC HEALTH EFFECTS COSTS WITH AVERAGE COMPENSATION LEVELS AWARDED IN RADIATION- AND ASBESTOS-RELATED LITIGATION

	Health Effects Costs per Injury[a]		
	Injuries	Fatalities	Cancers
Irene Allen vs. the U.S.[b]	e	$ 320,000	$100,000
Asbestos claims[c]	$ 54,000	265,000	83,000
NRC costs[d]	100,000	1,000,000	100,000

[a]With two exceptions, the health effects referred to here occur 10-40 years after exposure to radioactive materials. The exceptions are the NRC values for injuries and fatalities, which are characterized as occuring within the first year after exposure.

[b]These costs represent our calculation of the average amount paid to the 10 claimants in the 1984 settlement.

[c]The amounts awarded here represent average awards from cases closed between January 1980 and August 1982 as calculated by the Rand Corporation.

[d]These values were extracted from the 1982 NRC-sponsored study, Estimates of the Financial Consequences of Nuclear Power Reactor Accidents.

[e]Not applicable.

We concluded that $100,000 for early injuries and latent cancers and $1 million for early fatalities recommended in the 1982 NRC reports are reasonable estimates of health effects costs. Because these values generally equalled or exceeded those awarded by the courts, we also believe them to be conservative. In our judgment, a conservative estimate of health effects costs is consistent with the overall approach of probabilistic risk analysis.

With respect to the dollar value of off-site property damages, we reviewed the NRC studies' estimation of these costs, which was based on a refinement of the data used in the Reactor Safety Study, and included lost wages, relocation expenses of the

evacuated population, decontamination costs, lost public and private property costs, and interdicted land and farm crop values. Because the NRC studies contain the most exhaustive analysis of property damages performed to date, we accepted these estimates. The only modification we made to the property damage costs was to escalate them to 1986 dollars.

We then totalled the financial costs for health effects and property damages to produce a total value for off-site financial consequences.

Because consequences do not tell the whole story, we also calculated comparative plant risks (consequences times average probability) to determine which type of accident contributes most significantly to public risk. We found that catastrophic accidents dominate the risk to the public, and therefore focused the rest of our analysis on this type of accident.

At this time, we are not proposing a liability limit that should be established with respect to damages from a catastrophic accident. However, we did compare total consequences for all plants resulting from a catastrophic accident with the current limit and with limits proposed in House bill 3653 and Senate bill 1225 to determine the number and percentage of plants covered by each of those limits.

Finally, we studied the treatment of claims arising from the March 1979 TMI accident to determine how the Price-Anderson insurance system performed for this accident.

LIMITATIONS OF STUDY

- Uncertainties are inherent in the PRA method of estimating accident consequences resulting from:
  - --scarcity of data on accident behavior, equipment failures, and human response to accidents and
  - --assumptions regarding weather conditions, dispersion of radioactive materials, emergency response to an accident, and the relationship of dose to health effects.
- Scope of review was limited--some off-site costs covered by the Price-Anderson Act were not estimated, and on-site costs not covered by the Price-Anderson Act were excluded from our analysis.
  - --Other costs compensable by the Price-Anderson Act include the cost of investigating, settling, and defending claims for off-site damages.
  - --On-site costs, which are not covered by the Price-Anderson Act, relate to the purchase of replacement power, capital costs of carrying assets, on-site property damage and cleanup, and shareholder lawsuits.

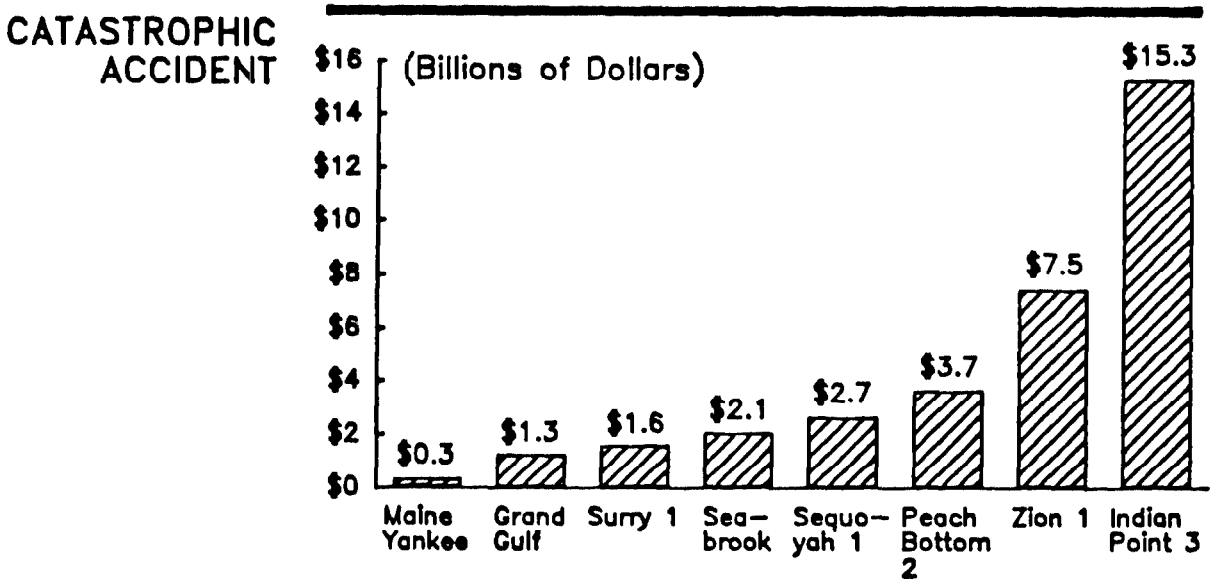
LIMITATIONS OF STUDY

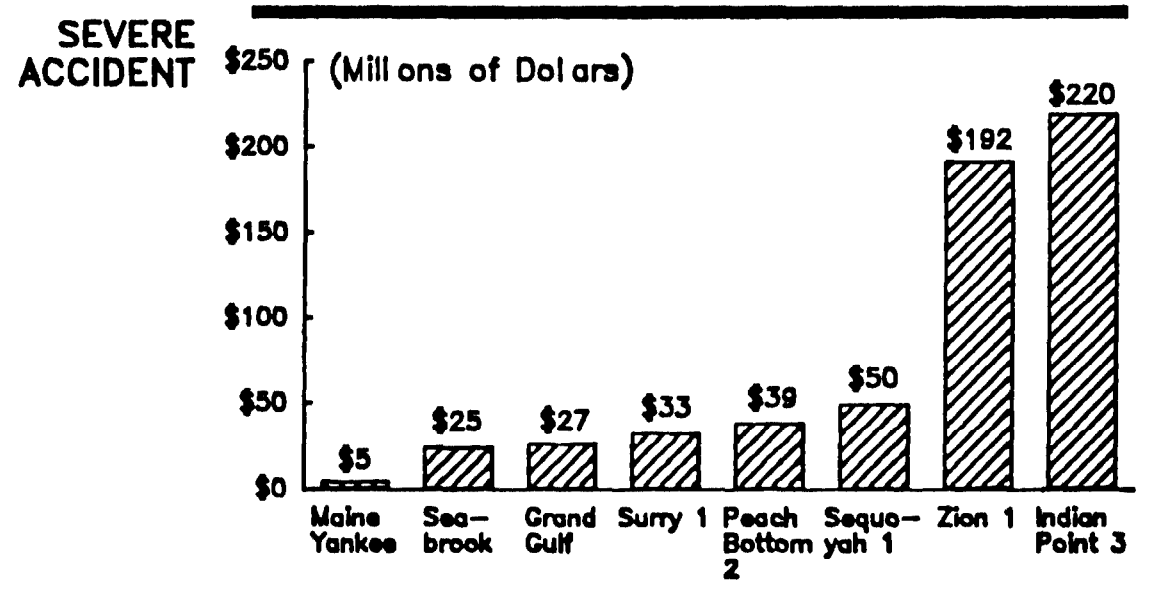
Our analysis has limitations in two areas resulting from the uncertainties in the consequence estimates themselves and from our limited scope. The uncertainties inherent in the PRA estimates of consequences stem from (1) scarcity of data on accident behavior, equipment failures, and human response to accidents and (2) assumptions made regarding weather conditions at the time of an accident, how radioactive materials would disperse, emergency response to an accident, and dose relationship to health effects. Nevertheless, NRC and others believe that the PRA approach to estimating consequences is the most systematic way to estimate consequences.

Our review did not estimate all costs associated with off-site damages nor did it estimate other costs associated with an accident that are not covered by the Price-Anderson Act, such as on-site costs and indirect economic losses. Specifically, we did not calculate the costs of investigating, settling, or defending off-site public liability claims, which are compensable under the Price-Anderson Act insurance structure. Also, since we were not requested to do so, we did not address on-site costs. These costs, which are not covered by Price Anderson but represent real costs of a nuclear plant accident, are costs the utilities would incur such as (1) replacement power purchased to compensate for the lost generating capacity, (2) the capital cost of carrying unused assets, (3) on-site property damage and cleanup costs that exceed insurance indemnification levels, and (4) the cost of any shareholder lawsuits. Finally, there may be other economic losses indirectly associated with a plant accident, which would be difficult to quantify, that we did not address. These could include losses such as the shutdown of other reactors and the temporary loss of industrial capacity and jobs outside the area directly affected by the accident.

FIGURE III.1

AVERAGE FINANCIAL CONSEQUENCES OF CATASTROPHIC AND SEVERE ACCIDENTS





SECTION III

AVERAGE FINANCIAL CONSEQUENCES OF CATASTROPHIC AND SEVERE ACCIDENTS

The range of average off-site financial consequences between nuclear power plants for a catastrophic accident is large, varying by billions of dollars. In comparison, the range of average financial consequences for a severe accident is small, varying in increments of millions of dollars. It is important to note that the values reported here represent average consequences for a wide range of weather conditions. According to NRC officials, atypical weather conditions are expected to result in consequences up to 10 times greater or less than those summarized here. The amount of the expected increase or decrease depends on the population around the plant.

The catastrophic and severe accidents discussed here are rare events. At any particular plant the estimated probability that a catastrophic accident will occur in a single year is 1 in 100,000. The estimated probability that a severe accident would occur is 2 in 100,000.[3] Once an accident has occurred, the consequences depend on the particular weather prevailing at that time, and, according to NRC officials, the most adverse weather conditions could increase the consequences by approximately 10 times. However, according to NRC officials, the worst weather conditions resulting in maximum consequences are 100 to 1,000 times less likely to occur than the weather conditions that result in average consequences.

In the discussion above, the probabilities for a catastrophic or severe accident are cited for a single typical reactor on an annual basis. NRC has also performed calculations in recent years which indicated the probability of an accident occuring involving a core-melt at any of the approximately 100 plants in operation. The most recent NRC analysis concludes that there is a 12 percent chance that an accident involving melting of the reactor core will occur in the next 20 years at a nuclear plant in this country. NRC's calculations do not include, however, any probabilities regarding the core-melt breaching the reactor containment and creating a severe or catastrophic accident.

Although the ranges of consequences are displayed here for only 8 plants, they encompass the accident costs for all 117 plants either operating or under construction, with the exception of 2 or 3 that fall below the low end of the ranges. In general, plant size, population density, and land use patterns determine where each plant falls within the range of consequences. These consequences represent the combined costs of health effects and property damages; however, property damages dominate the cost. For example, property damages represent 76-90 percent of the total consequences for average catastrophic and severe accidents.

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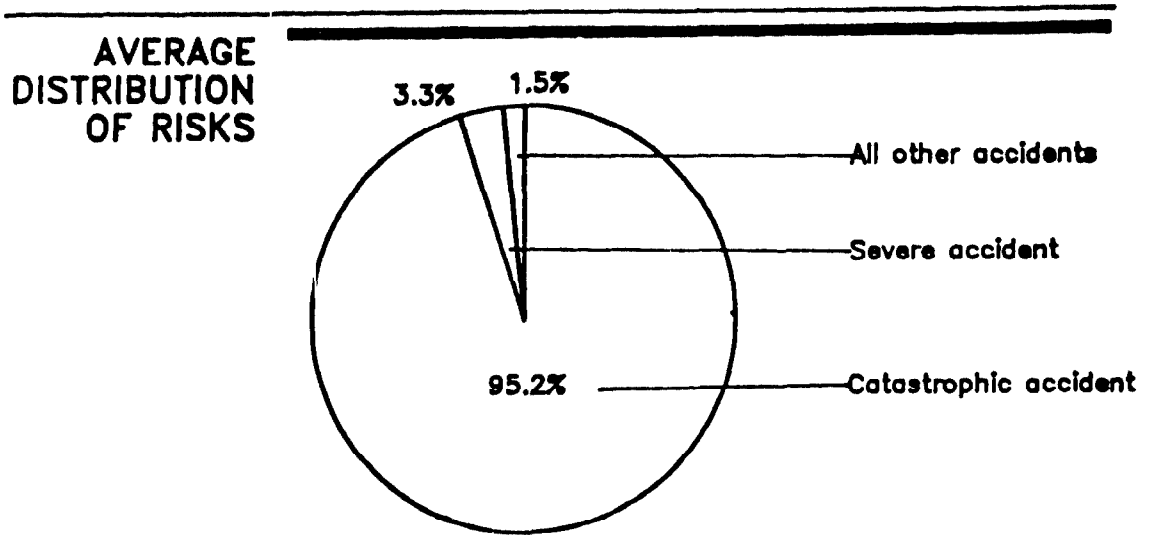
[3]The probabilities cited here are only representative. Based on currently available PRAs, NRC has suggested that the value that would be calculated at any individual plant might be different by a factor of 10 to 100.

FIGURE IV.1

CATASTROPHIC ACCIDENTS DOMINATE NUCLEAR ACCIDENT RISKS



SECTION IV

CATASTROPHIC ACCIDENTS DOMINATE NUCLEAR ACCIDENT RISKS

In selecting which accident consequences to compare with a Price-Anderson liability limit, we addressed the question of which accident, catastrophic or severe, posed the greater risk to public safety. Because neither consequences nor probabilities by themselves tell the whole story, one approach is to combine the two to estimate the risk.

On the basis of our analysis, the catastrophic accident dominates the risk to public safety. This is due to the combined effect of two factors: (1) the dollar consequences of this type of accident are larger by billions of dollars than the severe accident and (2) there is a relatively small difference in probability of occurrence between the two types of accidents. The probability of a catastrophic accident is on the order of one-half that of a severe accident.

Because the catastrophic event is the accident of significance in setting a liability limit under Price-Anderson, the remainder of our analysis concentrates on these consequences.

FIGURE V.1

COMPARISON OF AVERAGE ACCIDENT CONSEQUENCES OF ALL REACTORS WITH CURRENT AND PROPOSED PRICE-ANDERSON LIABILITY LIMITS

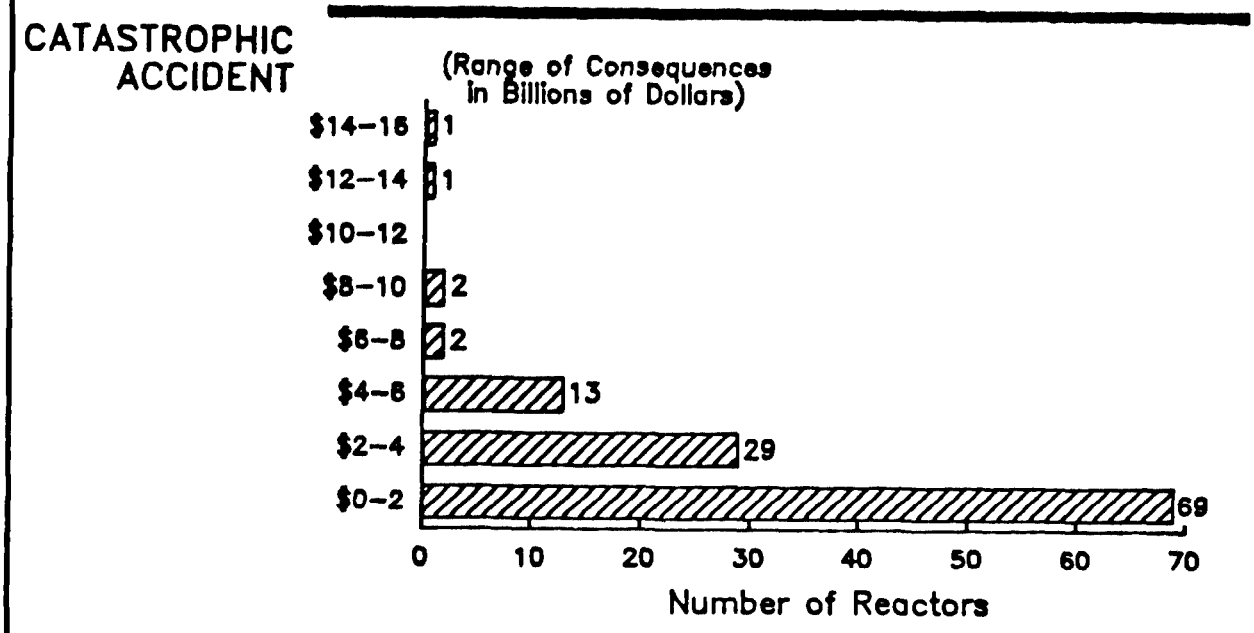


TABLE V.1
ACTUAL AND PROPOSED LIABILITY LIMIT COVERAGE OF A CATASTROPHIC ACCIDENT

	Reactors covered by limit	
	Number	Percent
Total number of reactors	117	
Current limit of $665 million	5	4%
S.1225 proposal of $2.5 billion	75	64%
H.3653 proposal of $6.5 billion	111	95%

SECTION V

HOW AVERAGE CATASTROPHIC ACCIDENT CONSEQUENCES COMPARE WITH PRICE-ANDERSON LIMITS

When we calculated off-site financial consequences for all 117 reactors, the majority (111 of 117) did not exceed $6 billion. The six plants that exceeded this amount were Indian Point 2 and 3, Limerick 1 and 2, and Zion 1 and 2 because of their proximities to the cities of New York, Philadelphia, and Chicago, respectively.

When compared with the existing $665 million Price-Anderson limit and the $6.5 billion and $2.5 billion limits proposed in H.R. 3653 and S. 1225, respectively, one can see that the existing limit covers 4 percent of the plants. On the other hand, a $2.5 billion limit would cover 64 percent of the plants, and a $6.5 billion limit would cover 95 percent of them.

It is important to recognize that we have compared average consequences with the current and proposed liability limits. As indicated earlier, according to NRC officials, the financial consequences of a catastrophic accident under severe weather conditions could be up to approximately 10 times greater than average consequences. Although very severe weather conditions are improbable, if they are considered in estimating financial consequences, even the limits proposed by the Senate and House bills might not cover the majority of the plants.

THE FINANCIAL CONSEQUENCES OF THE TMI ACCIDENT WERE WELL BELOW THE PRICE-ANDERSON ACT LIABILITY LIMIT

- o TMI presents the first test of the adequacy of financial protection under the Price-Anderson Act.
- o TMI was neither a catastrophic nor severe accident.
  - --No early illnesses or fatalities were reported.
  - --No off-site contamination of property occurred.
  - --Most of the damages were on-site.
- o The off-site financial consequences of the TMI accident were well below the present $665 million limit.
  - --$41 million has been paid to date in an out-of-court settlement for anticipated potential latent cancers and economic losses.

SECTION VI

THE FINANCIAL CONSEQUENCES OF THE THREE MILE ISLAND ACCIDENT WERE WELL BELOW THE PRICE-ANDERSON ACT LIABILITY LIMIT

For the Price-Anderson Act, the March 1979 TMI accident represents the first test of whether adequate financial protection is available for the public and the nuclear industry. No payments had been made (or claims filed) prior to TMI for public liability arising out of the operation of a licensed nuclear power plant.

TMI was neither a catastrophic nor a severe accident as defined in our report. It produced very low levels of radiation compared with those types of accidents. As a result, no claims for short-term radiation damage, such as early illnesses and deaths, have been reported and no claims of off-site contamination of property have been sustained.

Lawsuits in the wake of the TMI accident fall into two broad classes of claims. These are (1) claims relating to the future possibility of direct injuries that may occur in the future--as much as 20 to 40 years after the accident--such as radiation-induced cancers and genetic injuries, and (2) economic losses such as costs incurred in the precautionary evacuation from the area around TMI and alleged reduction of property values.

The financial consequences of the TMI accident are well below the $665 million liability limit in Price-Anderson. To date, approximately $41 million has been paid in an out-of-court settlement for TMI claims: $14 million for anticipated indirect health effects; $5 million to monitor the health of residents within 15 miles of TMI; and $22 million for economic losses sufferred by individuals. Since this settlement, an additional 2,000 personal injury claims have been filed.

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