Rulemaking Comments **PR 50 and 52 (74FR23253)** 6

From: Gallagher, Carol
Sent: Monday, July 13, 2009 2:32 PM
To: Rulemaking Comments
Subject: Comment on Emergency Preparedness proposed rule
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Van,

Attached for docketing is a comment from Herschel Specter on the above noted proposed rule that I received via the regulations.gov website on 7/10/09.

Thanks,
Carol

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RBR CONSULTANTS, INC.

COMMENTS ON THE NRC'S PROPOSED RULE ON EMERGENCY PLANNING

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July, 2009

COMMENTS ON THE NRC'S "PROPOSED RULE ON EMERGENCY PLANNING"

RBR Consultants, Inc.

ABSTRACT

The NRC has issued a notice in the Federal Register that it seeks comments on a Proposed Rule on Emergency Planning and has identified a number of issues that the Final Rule should address. This report is a response to the NRC request for comments and offers both general comments on the technology of emergency planning and specific comments on some of the issues identified in the Proposed Rule.

It is argued that the issues identified in the Proposed Rule represent far too small a scope for this important subject. Instead, the Proposed Rule should be the mechanism for modernizing emergency planning and building a much broader framework that reflects the fundamental guidance on this subject provided by NRC Chairman Jaczko in his April, 2007 speech, which is included as Appendix A. Chairman Jaczko emphasized the need to gain public confidence in emergency planning. A number of comments offered in this report identify areas where the public has been either under-informed or misinformed about emergency planning and nuclear risks, in general. Suggestions are given are how to correct this situation through better communication on specific topics.

The Chairman has also called for quantification of the effectiveness of emergency plans and procedures. Between the Chairman's speech in April, 2007 and now, two major advances in emergency planning technology have been made that permit such quantification.

One major advance in technology has been achieved through research sponsored by the NRC and conducted at Sandia National Laboratories (SNL). This SNL effort is the SOARCA program, an acronym for State-of-the-Art of Reactor Consequence Analysis. The SOARCA program is an important scientific advance in calculating source terms (how much, when, and what types radioactive material would enter the environment for different core melt sequences). The overall conclusion from this important SNL effort is that calculated releases of radioactive material into the environment would be much smaller and much later than thought before, so much so, that the SOARCA program could not identify any large, early release scenarios for a wide range of nuclear accidents. This means that nuclear accidents are extremely unlikely to cause a prompt (early) fatality. Nuclear power plants act much like large, complex filters that trap a major fraction of the radioactive material on site released by core melt sequences. Further, this filtering capability does not depend on active engineered safety features because it is the result of naturally occurring chemical and physical source term reduction processes.This natural source term reduction capability applies to both unintended reactor accidents and hostile acts of terrorism or sabotage **and can not be defeated by acts of terrorism, operator errors, or inoperable safety equipment.** If the pathway of the radioactive material previously contained in the fuel bypasses the containment, the plant would filter out 90% to 99% of the radioactive iodine and cesium. If the pathway to the environment passes through the containment, about 99% of the radioactive iodine and cesium would be filtered out.

The other major technological advance is described in the RBR report "Enhanced Emergency Planning", which is attached. Unlike the SNL effort that examined reactor accidents, the RBR report analyzed an assumed severe terrorist attack where it was postulated that a containment building was breached with a large hole, followed by a core melt sequence some 30 minutes later. This RBR analysis was for a large pressurized water reactor at Indian Point, the nation's most populated nuclear power plant site where evacuation would be very slow. Significant advances were made in the technologies of traffic analysis and in consequence analysis and in how to merge these two advanced technologies. Because of these technological improvements virtually all emergency planning actions can

now be quantified in terms of their impacts on radiologically induced health effects. The RBR report, independent of the SOARCA effort and using a different technological approach, also concluded that the early fatality risk is at or near zero even for postulated extreme, and assumedly successful, terrorist acts at the nation's most populated site.

Because of these technological advances permit quantification of emergency plans and procedures in terms of their impacts on limiting early and latent health effects the Chairman's goal of quantification in emergency planning has been achieved.

The Chairman also called for a "new radiological paradigm shift". With this new quantification capability, this paradigm shift is at hand. Since different emergency responses can be quantified according to their importance in limiting radiation induced health effects, these different emergency responses could be ranked in importance. Those with the highest ranking should receive the most attention, such as in emergency drills that would exercise their use. Such quantified, ranked, and focussed emergency drills should be a major element of the new radiological paradigm. Also part of this new radiological paradigm is the ability to relate the regulation of emergency planning to the regulation of systems, components, and structures and operator actions within the plant boundary. In other words, quantification in the new emergency planning regulatory paradigm creates a regulatory continuum that ties together safety activities within the nuclear plant to emergency planning outside of the plant. The benefits of having such a regulatory continuum are also discussed in this report.

Two other major areas have emerged as important emergency planning considerations. First, with the absence of an early fatality risk, a new technologically defensible way of establishing the size of the EPZ is needed. It is recommended that the size of the EPZ be established on the basis of the latent fatality risk and one methodology on how to do this is provided. Second, with the SOARCA program demonstrating that risks from <u>nuclear accidents</u> are exceedingly small, the emphasis for emergency planning appropriately shifts to preparing for <u>terrorist events</u>. This report merges the SOARCA technology with the RBR technology and presents a table (TABLE 4) of recommended emergency responses (for PWRs) to both accidents and hostile acts. Many of the specific issues identified in the announcement in the Federal Register are integrated on a common basis in TABLE 4.

Most of all, the Chairman's call for a "new radiological paradigm shift" should apply to more than emergency planning. The recognition that nuclear power <u>inherently</u> represents an extremely small risk to the public should be reflected in an expanded vision of this new paradigm. The conduct of business at the Commission should be broadly reviewed to assure that the public will benefit from a modern emergency planning process and that the burden of regulations and other restraints that do not significantly add to the public's protection be relaxed or removed. Examples of the latter are provided in this report.

In conclusion, Chairman Jaczko's guidance and advances in technology provide great opportunities for advancements in emergency planning and the Proposed Rule should be the vehicle by which these advances are realized. Further progress beyond emergency planning in advancing a more effective and efficient regulatory process should build upon the progress made in developing the Final Emergency Planning Rule.

Herschel Specter, President

RBR Consultants, Inc.

July, 2009

COMMENTS ON "PROPOSED EMERGENCY PLANNING RULE"

RBR Consultants, Inc.

List of Abbreviations

ALARA	As Low As Reasonably Achievable
ATWS	Anticipated Transient Without Scram
EAL	Emergency Action Level
EPA	Environmental Protection Agency
EPZ	Emergency Planning Zone
ETE	Evacuation Time Estimate
IPE	Individual Plant Examination
ISLOCA	Interfacing Systems Loss of Coolant Accident
LERF	Large Early Release Frequency
LNT	Linear Non-Threshold
LOC	Loss Of Coolant
LOCA	Loss Of Coolant Accident
MACCS2	MELCOR Accident Consequence Code System, version 2
NRC	Nuclear Regulatory Commission
PAG	Protective Action Guide
PRA	Probabilistic Risk Assessment
PWR	Pressurized Water Reactor
RY	Reactor-Year
SBO	Station Blackout
SGTR	Steam Generator Tube Rupture
SOARCA	State-of-the-Art Reactor Consequence Analysis
SSCs	Structures, Systems and Components
TMI	Three Mile Island
WHO	World Health Organization

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PROPOSED EMERGENCY PLANNING RULE

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COMMENTS ON "PROPOSED EMERGENCY PLANNING RULE"
RBR Consultants, Inc.

1.0 Quotation

"We are concerned about the impact of the evacuation plans for residents in the area. There is no realistic way for evacuation to occur, for a multitude of reasons. Even if successful, evacuees might not have a home community to which to return after such a massive evacuation. It is well-established that there is no safe level of radiation exposure from a power plant explosion, or just from on-going leaks, and the effects are cumulative." **(Reference 1).**

2.0 The Importance of Emergency Planning

2.1 Background

Emergency planning serves as part of the NRC's defense-in-depth cornerstone approach to nuclear safety. It is one of the major interfaces between the NRC and plant operators on one hand and the public and its elected officials on the other hand. Therefore one measure of the value of the Proposed Rule on Emergency Planning is whether or not it results in preparation and responses that, in the event of a release of radioactive material into the environment, ensures protection of the public's health and safety. Another measure is whether the public has received adequate information so that it has confidence in the emergency plan.

Achieving reasonable assurance of protection of the public's health and safety in today's world means that emergency planning must provide adequate protection from both unintended accidents and hostile acts of terrorism. Previous risk analyses of reactor accidents have long shown that the risks from nuclear power plants are very small compared to normal background risks.(See Figures 1 through 4). Recent research sponsored by the NRC at Sandia National Laboratory continues this trend towards ever smaller calculated risks from accidents at nuclear power plants. Therefore the focus of emergency planning is appropriately shifting towards responding to hostile acts of terrorism. This is timely in that terrorism issues, specifically the consequences of a large aircraft crash at a nuclear power plant, have been raised by people opposed to the construction of two new nuclear plants in Bay City, Texas. Terrorist issues have been raised at license extension hearings at a number of nuclear power plant sites. The Proposed Rule identifies various issues where improvements are sought, a number of which relate to security issues.

Whereas technical investigations, such as source term analyses and probabilistic risk assessments, have been applied to accident risk analyses and somewhat towards emergency planning to deal with such accidents, this level of technical support is absent in evaluating emergency responses to acts of terrorism. The NRC documents supporting the Proposed Rule do not appear to provide any quantitative analyses of postulated terrorist caused source terms, e.g., their timing and magnitudes, their conditional probabilities, or the possible impact of different terrorist events on onsite and offsite emergency responses. Therefore the technical underpinning for these issues comparable to that for reactor accidents is absent. ***Fortunately, the technology needed to analyze postulated successful terrorist attacks now exists and should be used to strengthen the Proposed Rule.***

The issues presently identified in the Proposed Rule also fall short of achieving the fundamental emergency planning principles expressed by NRC Chairman Jaczko in April, 2007 (Reference 2) wherein he called for better communication and quantification of the protection that emergency preparedness plans and procedures should provide. See Appendix A. None of the issues in the Proposed Rule has a quantitative underpinning. ***Judging by the quotation in Section 1.0 above, much needs to be done to improve communications and, as shown in the comments provided here, much can and should be done to quantify protective actions.***

Chairman Jaczko also spoke in 2007 of the "longer-term exploration of a new radiological emergency preparedness paradigm." Major paradigm shifts in the regulatory process have occurred before, such as evolving from a deterministic based set of regulations, implemented by prescriptive requirements to a performance-based, risk-informed approach to regulation. Lessons can be learned on how this earlier paradigm shift was accomplished to help judge whether it is now possible to achieve the new radiological preparedness paradigm the Chairman identified several years ago.

By the 1990s virtually every nuclear power plant had an individual probabilistic risk assessment (PRA) that quantified their risks and which could be used to identify those plant systems, structures and components (SSCs) that were most important to safety. In March, 1992 a public presentation was made to all five NRC Commissioners which used NRC sponsored PRA research to show, quantitatively, that a number of Commission requirements virtually had no risk significance while other risk significant issues in plant operation, specifically the control of plant configurations, had been largely overlooked. The availability of Individual Plant Examinations (IPEs) throughout the fleet of nuclear plants and this March, 1992 presentation precipitated a paradigm shift in the regulatory process. Once it became possible to quantify risk significance, this resulted in a much more focused regulatory process where safety was improved and costs were reduced.

With the history of the great regulatory progress that has been made once a quantitative approach was used to analyze unintended accidents, with improved technology now available to better quantify both the onsets of radioactive releases and their magnitudes of postulated terrorist attacks, with the new technology that can quantify the consequence impacts of different emergency responses, the time has come to implement the Chairman's new radiological emergency preparedness paradigm. ***It is strongly recommended that this Proposed Rule serve as the vehicle by which this new quantified paradigm on Emergency Planning expressed by Chairman Jaczko is brought into practice.*** Improving the specific issues in the Proposed Rule would naturally flow in a much more technically consistent and transparent manner if all were based on implementation of the Chairman's guidance for greater use of quantitative processes.

Three major tasks lie ahead that should be accomplished when developing a meaningful Final Emergency Planning Rule:

1. Modernize emergency planning using the best science available.
2. Review classified and unclassified plant security analyses. Separate different security challenges into groups as shown in TABLE 4. Analyze each group to determine the onset of releases of radioactive material into the environment and magnitudes of such releases using the technology developed by SNL in its SOARCA program, described below. Develop specific emergency responses to these security challenges, using SOARCA and RBR technology, also described below.

3. Significantly improve communication between the NRC and other federal agencies and the public and its elected officials about emergency planning and nuclear risks, in general.

In order to assure completeness and to encourage public acceptance, a broad review scope is recommended. Insights from actual accidents at nuclear power plants and their emergency responses and lessons learned from emergency responses to non-radiological events, such as Hurricanes Andrew, Katrina, Rita, Constance, and Ike should be part of the process by which a Final Rule is formulated. ***This broad scope should include responding to unintended core melt accidents and postulated terrorist events, including attacks on spent fuel pools, events involving reactivity excursions, and shutdown events with an open containment.*** Based on the most up-to-date research it is expected that most of these events, whether accidental or intended, would have very limited offsite radiological significance, but should be examined for the purpose of completeness and for assuring the public that this Proposed Rule effort has been comprehensive.

Even though the frequency of terrorist events is unknown, it is still possible to analyze these situations quantitatively with modern technology. Much of the advanced source term technology developed by Sandia National Laboratories (SNL) for accidental events is transferable to analyzing terrorist events. In fact, Sandia was the key contributor to the NRC's "Vulnerability Assessment" which was performed just after the 9/11 attacks. These earlier assessments were a "test bed" for the present SOARCA program. Sandia has also performed large scale testing of drained spent fuel pool events. Further, many emergency planning insights can be gained by analyzing events where only the conditional frequency of the event has been determined. The term "conditional frequency" as used here means that it is assumed that the probability that a terrorist attack would be initiated is 1.0. The conditional frequency is the calculated frequency that this attack proceeds from initiation to plant damage and finally to a release of radioactive material to the environment. Stated somewhat differently, "Given the condition that a terrorist attack has been initiated, what is the frequency that this attack would lead to a release of radioactive material into the environment?"

2.2 Analytical Approach to Radiological Emergency Planning

In order to approach emergency planning in a systematic way, potential releases to the environment are divided into two main areas. One area focuses on unintended accidents and the other on intended hostile attacks. The recent SNL SOARCA effort concentrates on unintended accidents while the RBR report, described in more detail below, is largely directed at a hypothetical extreme terrorist event. As mentioned above, the technology developed by SNL has its roots in analyzing postulated terrorist events. Similarly, the RBR approach could be used to analyze offsite emergency responses to both terrorist events and unintended accidents. If these two studies were combined or if SNL would expand its study to follow the RBR methodology, the technical underpinning for a new radiological emergency preparedness paradigm would be at hand.

Comments on the Proposed Emergency Planning Rule are divided into General Comments on the Technology of Emergency Planning in Section 2 and Specific Comments in Section 3 where several areas identified in the Proposed Rule are discussed. To assist the reader, recommendations are presented in bold, Italic type.

3.0 General Comments on the Technology of Emergency Planning

3.1 The best science

Consistent with the directives of the President, the best science should play a major role in decision making and in developing the Final Rule. In the context of emergency planning the best science should be applied to the sources of radiation and to the time dependent locations of people and the protective actions that they would be taking. When the best science is applied to both sources and the locations of receivers, this leads to the best emergency planning, the best regulatory practices, and the most protection of the public.

The best source term science today is the NRC's sponsored program at Sandia National Laboratory, "SOARCA", or "The State-of-the-Art for Reactor Accident Consequence Analysis". The SOARCA effort is the most up-to-date analysis of the types of radioactive species that might be released into the environment from different beyond design basis core melt scenarios from different classes of light water reactors, BWRs and PWRs. It is based on a wide range of national and international experiments, advanced analytical techniques, far more detailed descriptions of the internals of the reactor vessel and the containment building, and a more extensive operational data base. SOARCA analyses determine, per scenario and reactor class, the onset of releases into the environment, the duration of these releases, and their magnitudes. Other parameters that affect consequence analyses, such as the internal energy of the released radioactive plume, can be derived from these analyses. The SOARCA effort also quantifies the frequencies of these release scenarios. Since both frequencies and consequences are computed, risks can be estimated.

The SOARCA program used the Peach Bottom and Surry plants as their reference BWR and PWR, respectively. This permits direct comparisons with WASH-1400 (Reference 3) and NUREG-1150 (Reference 4) which analyzed the same plants. Each successive analysis, based on ever larger experimental and operational data bases, showed smaller and smaller early fatality consequences and risks. See Figures 1 through 4, which were adapted from the ACRS white paper "Historical Perspectives and Insights on Reactor Consequence Analyses", November, 2008. Figure 1 shows the background total early fatalities and the contributions to the total from natural causes and those caused by man. The societal risks given in the figure are 95% complimentary cumulative distribution function values. That is, these show that the (actual) consequences have a 95% probability of exceeding the given values.Thus, the plotted values are lower limits of societal risks. Figure 2 repeats the societal risks and compares them with the NRC safety goal as originally conceived. That is, the early fatality risk to the public from nuclear power should not exceed 0.1 percent (0.001) of the risk from background sources. This plot of the NRC's early fatality safety goal is itself conservative because it is based on the conservative 95% complimentary cumulative distribution curve for background early fatality risks. Figure 3 shows the NRC early fatality safety goal with the risks calculated by WASH-1400 for the Surry plant. This indicates that the WASH-1400 values are well below the safety goals. Figure 4 shows the WASH-1400 values for Surry and the newer, much smaller, NUREG-1150 values, which indicate a risk about one millionth of the early fatality safety goal. Figure 4 also shows the estimated values from the SOARCA project and the RBR values where the early fatality risk is at or near zero. Therefore we have known since the mid 1970s that the health risks from nuclear power plants are extremely small and further analyses and operating experience indicate that the newest values for nuclear power plant risks are below the NRC safety goals by very large margins.

Therefore, with each successive analysis the calculated risk reduction potential for emergency planning has decreased. ***This trend and the very small calculated risks argue for simplification of emergency planning and this should be reflected in the Final Rule.***

3.2 Co-existence

A fundamental concept in emergency planning is co-existence which ties together many of the issues identified in the Proposed Rule. In order for there to be a possible radiation-induced health effect two events have to co-exist. First there has to be a source of radiation at a particular location and second these has to be a receiver (i.e., a person) at this location during the same time period that the source is there. In general, the number and types of radiation induced health effects is a function of the intensity of the sources of radiation, the number of receivers, the length of time that both co-exist, and the protective actions that are taken.

This simple co-existence concept integrates the only two actual nuclear accidents, TMI-2 in 1979 and Chernobyl in 1986. Co-existence also integrates various analyses of postulated releases ranging from WASH-1400 to those in NUREG/CR-2239 ("The Sandia Siting Report") (Reference 5), to NUREG-1150 and utility sponsored PRAs, to the modern analysis in Sandia's SOARCA program (Reference 6).

The TMI-2 accident had essentially no co-existence because the release of radioactive material into the environment resulted in very low doses and the corresponding health consequences were effectively zero. In the often misused analyses in the supporting material of the Sandia Siting Report where large consequences were postulated, co-existence was unrealistically maximized by assuming the release of a very large source term (SST-1) (Reference 5), then having all of this radioactive material rain on a distant population center where people stood outside for 24 hours without any protection. Other postulated consequence analyses have been published like "Chernobyl on the Hudson" (Reference 7) which makes unrealistic, and even impossible, assumptions that increase co-existence well beyond those in the Sandia Siting Report's supporting analyses. This unscientific analysis claimed that up to 44,000 early fatalities and 518,000 latent fatalities could occur from an accident or terrorist event at Indian Point in Buchanan, New York. All reactor accidents, actual and postulated, and releases of radioactive material from hypothetical terrorist events fall between TMI-2 and "Chernobyl on the Hudson", with the great preponderance of science-based consequence analyses falling within or close to the TMI-2 consequences.

To be more precise, the determination of co-existence differs for early health effects and latent health effects. This is because the distance from the point of release over which early health effects might occur is quite short, typically between zero and one mile, as shown in the RBR report and elsewhere, whereas latent effects have an indefinite range, unless a radiation level threshold is assumed below which no latent effects would be expected. There are several ways that a zero co-existence situation might occur for early fatalities, one of the classic parameters by which nuclear accidents are quantified. One, already identified for the TMI-2 accident, occurred when the source term is too small to cause an early fatality regardless of the emergency response. When the average release fraction of iodine, tellurium, and cesium is less than 5% of the reactor core's inventory of these radioactive elements, early fatalities are very unlikely regardless of the emergency response. Accident scenarios with an intact containment and others where chemical and physical processes trap much of the radioactive material within the nuclear plant, such as many late releases, fall into this very small source term situation. TABLE 1 below, shows that most of the postulated accidents analyzed in the SOARCA program would have average release fractions below 5% of the iodine, tellurium, and cesium core inventory and therefore would not result in a calculated early fatality regardless of the emergency response. Another zero co-existence situation for early fatalities occurs when there are essentially no people (receivers) within the range of the early fatality risk. This range is essentially zero miles for the accident sequences studied in the SOARCA program and up to about one mile from the point of release in the terrorist scenarios studied in the RBR effort. Zero co-existence would be the case for most nuclear sites because of the low surrounding population levels near the site. Third, zero co-existence would occur if all the people within one mile of the point of release were evacuated prior to the onset of a release. Using the results from the SOARCA analyses, shown in TABLE 1, none of the onsets of releases are calculated to occur less than 3.5 hours after sequence initiation. An onset time of 3.5 hours would be more than sufficient to evacuate people within one mile of the point of release for almost all nuclear power plant sites. Finally, even with some co-existence, exposure levels might not be high enough to cause an early fatality. For example, people might receive some exposure while sheltering prior to evacuating and additional exposure while evacuating. However, this cumulative exposure might still be below the early fatality threshold for early fatalities. Whole body doses as high as 200 rem are very unlikely to cause an early fatality, even with minimal medical treatment. The present results of the SOARCA program, described below, where core melt accidents either do not lead to releases to the environment, or have small source terms, and/or have long times before the onset of a release, means that the possibility of causing an early fatality is limited to a few high population sites with very slow evacuations and then only under unlikely weather conditions and with large releases exceeding 5% of the reactor core's inventory of radioactive material. The RBR report (Reference 8) shows, even the highest population site, Indian Point, has a near zero chance of producing a single early fatality even with very slow evacuations with speeds often below typical walking speeds. Therefore the main radiological benefit of emergency responses is to limit exposures that might lead to long term (latent) health effects. As discussed later, the latent fatality risk should therefore be the basis for establishing the size of the Emergency Planning Zone.

The two major considerations in determining co-existence, the source term characteristics and the time dependent locations of people who might be exposed to radiation, are embodied in the SOARCA and RBR technologies, respectively. These two state-of-the-art technologies are discussed further in Sections 3.3 and 3.4, below.

3.3 SOARCA results

The SOARCA effort provides large scale insights into reactor accidents such as which types of reactor scenarios have the potential to release radioactive material into the environment and which do not, why postulated accident progressions proceed much more slowly than previously thought, and why postulated releases are much smaller than previously thought. All of these insights bear on emergency planning and the calculation of nuclear risks. SOARCA is a major scientific achievement and fundamental to an accurate determination of the risks, co-existence, and emergency planning, in general. ***The Final Rule on Emergency Planning must reflect this NRC advance in science.*** A synopsis of some key results from the SOARCA analyses is presented below in TABLE 1. This synopsis is an adaptation of the information presented by the NRC and Sandia slides during the 21st Regulatory Information Conference on March 11, 2009 in Washington, D.C.

Table 1 SOARCA Results for Unmitigated Accidents

Plant	Event	Frequency, per reactor year, of a core melt situation.	Onset of release to the environment, hours, after sequence initiation.	Iodine release fraction	Cesium release fraction
Peach Bottom	Long term station blackout	$3(10)^{-6}$	20	~0.030	~0.020
Peach Bottom	Short term station blackout	$3(10)^{-7}$	8	~0.100	~0.020
Surry	Long term station blackout	$2(10)^{-5}$	45	~0.006	~0.001
Surry	Short term station blackout	$2(10)^{-6}$	25	~0.010	~0.005
Surry	Steam generator tube rupture	$5(10)^{-7}$	3.5	<0.010	~0.010
Surry	Interfacing systems LOCA	$3(10)^{-8}$	10	~0.100	~0.090

3.4 RBR technology

3.4.1 Methodology

Another large advance in the science of emergency planning is in offsite traffic analysis which determines the time dependent locations of evacuating people. An example of this advance in traffic analysis is described in the attached RBR report. KLD Associates[1] developed advanced traffic analyses. The traffic analysis in the RBR report was based on an actual site, the Indian Point Emergency Planning Zone (EPZ), and used the most recent population data, measured road widths and configurations, people-to-car ratios, and so forth. Because the areas nearest the site are most important radiologically, an extra fine traffic mesh was used there. In those locations the size of the mesh in this traffic analysis was about 0.2 square miles. Some 357 starting locations were

[1] KLD Associates is an internationally recognized transportation engineering firm located in Commack, New York. In 2007 it won a national engineering award from the American Council of Engineering for its advanced work on Indian Point.

considered in the KLD analysis, each with its own specific population level and location. Many traffic scenarios were investigated to determine the importance of mobilization times, how evacuation speeds are affected by the number of people who remain in a sheltered mode when requested, the importance of shadow evacuation, the importance of pedestrian evacuation routes, the value of precautionary evacuations, time of day/week impacts, sheltering versus evacuation, the importance of making specific road segments temporarily one way and outward bound, and so forth.

The RBR report also describes technological advances made in consequence analyses. Many previous consequence analyses have been based on a greatly simplified evacuation model, as contained in the MACCS2 consequence code. This simple MACCS2 evacuation model assumes that all evacuees start their evacuation at the same moment and evacuate at a constant speed in either a radial or circumferential direction. Typically, a single MACCS2 calculation has been the basis for previous consequence analyses.

Clearly the evacuation model built into the MACCS2 code is very simplistic compared to the sophisticated KLD analysis. Other technological advances had to be made which permitted the integration of the sophisticated KLD analyses into the MACCS2 consequence code. All of the previously mentioned MACCS2 evacuation modeling limitations were overcome. For example, instead of assuming that everyone started their evacuation at the same moment, a time dependent stream of people leaving each starting location was determined, based on KLD empirical data. Various "cohorts" of people left each starting point until the starting point was empty. Each cohort traveled its own path at speeds and directions determined by the KLD traffic analysis.

To blend the KLD analysis with the simpler MACCS2 evacuation model, the KLD traffic analysis was restructured into a pseudo road network that just used radial and circumferential movements to match the evacuation directions permitted by the MACCS2 code. The travel time between any two points along a pathway in this restructured KLD model was normalized to match the travel time calculated using the more precise KLD actual road network analysis between these two points. Since the mesh size was very small near the site and very small time steps were taken, a high degree of precision was maintained.

Instead of just radial evacuations as most MACCS2 analyses use, the RBR analysis used advanced MACCS2 analyses techniques integrated with the restructured KLD traffic analysis. These advanced MACCS2 analyses calculated radiation exposures for all "cohorts" which individually travelled down pathways based on the road networks surrounding Indian Point. This meant, analytically, that some evacuees were never within the plume while others travelled in the same direction as the plume for a period of time and then travelled perpendicular to the plume at other moments, as dictated by the actual road configurations. When traveling perpendicular to the plume, the time to cross through a narrow plume (the type of plume that is closest to the point of release and most concentrated) would be very short, a matter of minutes, even at very slow evacuation speeds. This far more accurate determination of the evacuation pathways and times of exposures resulted in far fewer calculated early fatalities compared to the "standard" MACCS2 analyses. "Standard" MACCS2 modeling causes a portion of the radially evacuating population to line-up with the centerline of the narrow plumes where radiation levels are the highest. This simplifying analytical arrangement greatly overestimates the time that a number of people that might receive high radiation exposures. In one simple comparison of the "Standard" MACCS2 way of calculating the number of early fatalities to the more precise way used in the RBR report, the "standard" MACCS2 methodology calculated 124 early fatalities at Indian Point while the more precise MACCS2 method calculated 2 early fatalities, both at the 95% weather condition, i.e., 95% of the time the consequences would be smaller than this value.

The above RBR approach led to a separate MACCS2 computer run, one per cohort, per scenario. Since the number of starting locations, cohorts, and subsequent pathways in the KLD analyses per traffic scenario was quite large and many traffic scenarios were investigated, the number of MACCS2 computer runs was very large. Not only was handling such large number of MACCS2 analyses a challenge, one can not simply add the health consequences from each cohort to get an aggregate health effects figure per scenario. This is because different cohorts travel different evacuation pathways. The meteorological data base in MACCS2 represents 8760 different situations, i.e., one per hour. The 90th percentile consequences for one cohort along its pathway would likely occur on a different day from another cohort's 90th percentile consequences since it travels down a different pathway and experiences different meteorological conditions. Technological advances were made to permit the addition of consequences from multiple MACCS2 calculations. In each of these MACCS2 analyses the exposure to radiation was determined for each cohort using a single weather scenario at a time. Consequences were then aggregated for all cohorts for this single weather scenario.This process was repeated until all weather scenarios in the MACCS2 data bank for Indian Point were analyzed and the resulting consequences were then summed and ranked. Final results were presented at the mean, 90th percentile, and 95th percentile weather conditions, for many traffic scenarios. Polestar Applied Technology[2] performed the MACCS2 analyses and created the methodology by which the multiple MACCS2 runs from a single accident scenario and a single traffic scenario could be combined. Integrating advanced traffic analysis with advanced multi-MACCS2 analyses is unique.

3.4.2 Analysis of terrorist/hostile action events

Polestar Applied Technology also generated the source terms that were used in the RBR analyses. These source terms were developed to represent releases from one of the Indian Point power plants for a loss of coolant event and for a station blackout event. In both cases it was assumed that some terrorist attack had occurred which breached the containment building, creating a very large hole. Then, a half hour later one of these core melt sequences was assumed to be initiated. For each of these two melt down scenarios, multiple traffic scenarios were combined with the MACCS2 code in the manner described above and early health effects were calculated. In a few selected cases latent health effects were also calculated. These traffic scenario-dependent consequences are compiled in the RBR report. This compilation produced many insights. For example, it was possible to compare the calculated health consequences of a traffic scenario where everyone in the EPZ was assumed to evacuate to another traffic scenario where all people within four miles of the site evacuated, with 35% the balance of the EPZ population also evacuating. Those people beyond four miles who did not evacuate were assumed to take shelter. The difference in

[2] Polestar Applied Technology, Inc. is a project management and engineering analysis firm based in Los Altos, California.

calculated health effects between these two scenarios is a measure of the value of having a large fraction of the EPZ population, about half, take shelter for a specific accident scenario. In other words, this approach quantified, in terms of health effects, the consequence importance of sheltering 65% of the population beyond four miles compared to an all-evacuation response.

Today it would be a straight forward exercise to combine a SOARCA source term analysis of a core melt down scenario assuming an initially open containment with any of the different traffic responses reported in the RBR document. Such an effort would use the best science and should provide upper bound early and latent health consequences for terrorist events since Indian Point is located at the nation's most populated site.

Even though the RBR analysis used source terms somewhat larger than those calculated in the SOARCA program for Surry, had much earlier onsets of releases, and had very slow evacuation speeds, this most populated site in the nation still had near zero calculated early fatalities, largely because of its sophisticated traffic analysis and improved MACCS2 and source term modeling. **Both the SOARCA analyses and the RBR report independently have concluded that the early fatality risk is essentially zero for those members of the public that participate in the emergency response. This fundamental conclusion bears on the need to stockpile KI pills and many other aspects of emergency planning.**

It is strongly recommended that the Final Rule be based on the best science. A very valuable exercise would be to analyze the various terrorist attacks listed in TABLE 4, using a combination of SOARCA derived open containment source terms and RBR traffic and multiple MACCS2 consequence analyses, and again assuming this attack occurred at the Indian Point site.

3.5 Quantification - an essential element required in the Proposed Rulemaking

In his April, 2007 presentation NRC Chairman Jackzo stated "let us quantify the protection that emergency preparedness plans and procedures should result in." (Appendix A) The present approach to emergency planning is largely a set of unquantified deterministic requirements to be implemented through prescriptive measures. This is the same approach that was used to regulate systems, structures, and components (SSCs) and operator actions within nuclear power plants until the early 1990s. As mentioned before, in early 1992 the regulatory process began a major shift towards a performance based, risk-informed style of regulation. This improved form of regulation increased safety while making better use of NRC and licensee resources. This large regulatory improvement became possible in the early 1990s because of the use of modern technology. of each IPEs (Individual Plant Examinations). These IPEs used probabilistic risk assessments to calculate core melt frequencies, also called a level 1 analysis, and in a number of cases these IPEs included level 2 analyses, which determines the frequency of releases of radioactive material to the environment. These IPEs, along with advances in source term technology, enabled both the Commission and the licensees to quantify the safety significance of SSCs and operator actions. Once plant features like pumps, valves, electrical buses, etc. were quantified according to their safety significance, resources could be expended in a manner that gave greater emphasis to the more risk significant plant features and operator actions. Many regulatory improvements evolved out of this improved process, such as the risk-informed Maintenance Rule. The NRC inspection process became more transparent, more consistent, and more focussed on what was most important to protecting the public. Simultaneously, nuclear utilities were able to focus on those actions that would be most effective the public's health and safety and in reducing the likelihood of plant damage. There have been comparatively few industry sponsored level 3 analysis that took the results of level 2 analyses and used them to determine offsite health and economic consequences of accidents at nuclear power plants. The RBR report represents a major industry effort to advance level 3 technology.

As demonstrated in the RBR report, it is now possible to quantify virtually all emergency response measures in terms of their impacts on early and latent health effects. Once quantified, these emergency responses can be ranked according to their significance and resources can be expended accordingly. Simply stated, emergency planning is at the threshold of a major paradigm shift with potential safety benefits and cost reductions that parallel the experiences of the NRC and nuclear industry once the benefits of quantification were applied to plant features and operator actions in the early 1990s. ***This approach should be applied in the Proposed Rule Making.***

With this new quantification capability, the importance of long evacuation mobilization times, the benefits of widening specific segments of nearby roadways, the effects of delays in commencing alerting and public notification, the importance of shadow evacuation, when and where to use a sheltering response, where to locate reception centers, the identification of what kind of and how many resources are needed (buses, medical support, etc.) can be calculated. Further, these technological advances provide a modern basis for establishing the size of the emergency planning zone (EPZ). It is even possible to quantify the overall safety significance of emergency planning itself by comparing the calculated consequences of a preferred emergency response, as listed in TABLE 3, to a case where there is a complete failure of the emergency plan (normal activities for 24 hours after the onset of a release into the environment.) In the specific case of Indian Point a total failure to have an emergency response could lead to about 1117 latent fatalities (mean value) for a station blackout scenario with a breached containment versus about 23 latent fatalities if a reference emergency planning response is implemented. For the smaller loss-of-coolant event with a breached containment, the mean number of latent fatalities drops from 770 to 114 when going from no emergency response to the reference emergency response. The safety significance of individual protective actions can likewise be quantified as to their impacts, if any, on the early and latent fatality consequences.

3.5.1 Examples of a quantitative approach

To illustrate this advanced quantification capability, calculated early and latent fatalities based on the RBR report are presented below in TABLES 2 and 3, respectively, for two extreme terrorist scenarios. These scenarios were based on the assumptions that one of the nuclear power plants at the Indian Point site was successfully attacked. In both scenarios it was assumed that, somehow, the massive containment structure was breached resulting in a large hole in it. It was further assumed that either a station blackout (SBO) or loss of primary coolant (LOC) core melt sequence was initiated just one half hour after the loss of containment integrity. Finally it was assumed that all this occurred during Monday to Friday daytime hours when the EPZ population level would be at its peak and evacuation would be slowest. These consequences only apply to Indian Point. Other, less populated, sites would have smaller consequences.

TABLE 2 shows that even for such extreme scenarios and 100% of the EPZ population evacuating, the number of early fatalities at the 95% weather condition is 5 people, with 203 early injuries[3] (Case A_). Therefore the early fatality risk, even for this site, is extremely small. If selected roads are made temporarily one way and outward bound (Case B1_) there would be a small decrease in the number of calculated early fatalities and an appreciable decrease in the number of early injuries. The SBO source term (Case S1) is larger than the LOC source term, but because its onset time is longer, many people would have evacuated from the inner one mile by the onset time. This longer time to begin to release radioactive material into the environment compared to LOC releases resulted in fewer calculated early health effects. The slower developing SBO scenario ended up with less co-existence. Case B2 shows the importance of sounding the alarm quickly in the early release sequence assumed here. Case C1 illustrates the benefits of a mix of inner prompt evacuation and sheltering 65% of the population beyond four miles for the extreme scenario analyzed here. With fewer people evacuating, consequences relative to 100% evacuation (Case A_), are appreciably lower. This comparison of Cases A_ and C1 shows that 100% evacuation at a high population site is not the optimum response. This also underscores the need to avoid EPZ wide ETE analyses which can promote the wrong message. Case Z1 illustrates the benefits of a precautionary evacuation of the inner one mile. This supports the precautionary evacuation recommendation in TABLE 4 for terrorist events, like a hijacked airplane at some distance, which have not yet caused damage on the nuclear plant. Lastly, Case Z2 shows that if there is hostile action at the plant site and people take shelter for a number of hours to avoid the dangers of this hostile action, the radiological consequences of a release could be higher than the more effective prompt evacuation of the inner area near the plant. However, this radiological "penalty" for sheltering would only begin after the onset of the release and may never occur if the containment is not breached. Therefore this response could very well result in fewer consequences than trying to evacuate "under fire". On balance, temporary sheltering of everyone in the EPZ during hostile actions at the site seems to be the preferred emergency response. Case Z2 is supportive of recommended response 2 in TABLE 4.

Note also that these figures are for a 95th percentile weather condition. If consequences in TABLE 2 were presented as mean values they would be smaller than these figures. Somewhat larger consequences are possible, such as at the 99th or 100th percentile. However these larger consequences are less likely to occur and could be a poor basis upon which an emergency plan might be developed. Using peak consequences to develop an emergency plan would be inconsistent with a long term emergency planning "philosophy" to assist most of the people, most of the time. If the release of radioactive material occurred at night or on weekends the evacuation would be more rapid due to the smaller population at risk and consequences would be lower.

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[3] Early injuries, as defined in NUREG/CR-2239 Reference 5 on page 2-5, are "non-fatal, non-carcinogenic illnesses, that appear within 1 year of the exposure and require medical attention or hospital treatment." The RBR analyses used a much more conservative criterion for determining if an early injury might occur, i.e., anyone calculated to receive a whole body dose of 50 rem or more was classified as having an early injury.

Table 2 Quantification example: different protective actions vs. early health consequences

Case	Source term	Emergency response	Early fatalities @ 95% weather condition	Early injuries @ 95% weather condition
A_	LOC	100% evacuation of 10 mile EPZ.	5	203
B1_	LOC	Same as A_, but with selected roads one way, outward bound/	4	80
S1	SBO	Same as B1_, but with larger, but later, SBO source term.	0	2
B2	LOC	Same as B1_, but with 0.5 hours more warning time.	1	28
C1	LOC	100% evacuation out to 4 miles, 65% of the downwind population shelters between 4 and 10 miles while 35% of the downwind population evacuates, others not downwind stay indoors, selected roads one way, outward bound.	2	33
Z1	LOC	Precautionary evacuation of inner one mile prior to loss of containment integrity.	0	~30
Z2	LOC	Shelter inner four miles for 3 hours then evacuate, 95% of EPZ downwind population beyond four miles assumed to shelters, others stay indoors, selected roads one way, outward bound.	39	141

Table 3 Quantitative example: different protective actions vs. mean latent health consequences

Type of response	LOC, mean number of latent fatalities	SBO, mean number of latent fatalities.
No response, normal activities for 24 hours.	770	1117
Evacuate inner one mile only, normal activities beyond one mile for 24 hours.	495	882
Reference response: Evacuate inner two miles and keyhole area out to four miles, beyond four miles to the EPZ boundary, downwind people should shelter for 4 or more hours, traffic controls should be implemented on selected roads to make them one way and outward bound. One hour assumed between start of attack on containment and sounding the public alert.	114	23
As above, but with half hour between start of attack on containment and sounding the public alert.	82	~5

It should be noted that the calculated postulated consequences in TABLES 2 and 3 are specific to Indian Point. The 0-10 mile population at Indian Point is 366,866 people, of which some 80,711 are expected to develop latent cancer fatalities from natural causes during their lifetimes. The probability of a successful terrorist attack is quite low, whereas the probability of these background cancer fatalities is about 1.0. Risks are usually expressed as the product of consequences times probability (or frequency). Therefore the latent fatality risks from Indian Point are very small compared to natural background latent cancer fatality risk. TABLE 3 is expressed as mean values, not 95% weather consequences, which would be larger. The selection of mean values in this table was based on the thought that, mathematically, it is the "expected" value and is more consistent with "expected" latent fatalities from natural causes, thereby permitting more appropriate comparisons.

3.5.2 An integrated regulatory process

This new ability to quantify emergency responses in terms of early and latent health effects produces **a regulatory continuum**. The basic process of quantifying and then ranking SSCs and operator actions in terms of their impacts on early and latent health effects matches quantifying and ranking specific emergency responses in terms of their impacts on early and latent health effects. Quantifying and ranking SSCs and operator actions inside a nuclear plant and now quantifying and ranking activities that affect emergency responses in the same early and latent fatality metrics is especially beneficial. These metrics are the same as those used in the NRC's health safety goals. With this new advance in quantification the whole regulatory process can be integrated in a consistent and transparent manner. In April, 2007 Chairman Jaczko spoke of "...and the longer- term exploration of a new radiological emergency preparedness paradigm".

That longer-term moment of a new radiological emergency preparedness paradigm has come. For example, because there now can be a regulatory continuum, equivalencies could be established, if desired, i.e., "What decrease in an accident's frequency and/or the source term due to a design or procedural change within the nuclear plant has the same safety significance as a specific offsite protective action or even the whole of emergency planning?" For example, using the data in TABLE 3, the ratio of the calculated number of latent fatalities for a no emergency response for 24 hours and the reference emergency response for a LOC sequence is 770/114 = 6.8. If plant safety modifications reduced the frequency of a LOC type release was reduced by a factor of 6.8, the resultant risk reduction value would match that the risk reduction value of the whole offsite emergency response. Such comparisons lend perspective to the whole subject of emergency planning.

Just as NRC inspections became more focussed once the safety significance of different SSCs were determined, better emergency drills can be formulated based on the rankings of different emergency responses. For example, it may be that quantification of a precautionary evacuation of the innermost one mile shows that it is the most effective consequence-reducing emergency response for high population sites under certain terrorist threat conditions. Assuming that this is the case, emergency drills might therefore concentrate on simulating limited precautionary evacuations. Precautionary evacuation of the innermost one mile may be particularly important in responding to potential terrorist events where actual damage to the reactor fuel has not yet occurred or may not actually ever occur. A case in point might be where a large aircraft has been hijacked but is still several hundred miles away from a potential strike on a nuclear plant or where there appears to have been an intentional local loss of offsite power. Such situations may call for a precautionary evacuation of the innermost one mile. (See TABLE 4 and Section 3.6.4)

Similarly, enforcement actions could become more quantified and consistent. For example, suppose that an emergency drill experiences a delay of 20 minutes in alerting the public to start an evacuation of the area nearest to a nuclear plant and that this delay is calculated to have ten times the potential health consequences of a failure of a siren to work for 20 minutes several miles from the site where people would normally take shelter in an emergency. It would be logical that an enforcement structure based on measured performance would consider a fine ten times larger for the 20 minute delay in alerting people near the site than the same delay from a defective siren at a much greater distance from the site. ***Further, enforcement actions tied to deficiencies exhibited in emergency drills, such as fines, should be comparable to enforcement actions inside the power plant if both are concerned with lapses of similar consequence significance.*** Establishing equivalencies in enforcement actions both within the power plant and offsite would bring a greater degree of consistency to the regulatory process.

The SNL SOARCA results and the RBR report point to the need to re-evaluate existing NRC regulations and guides, beyond the limited approach being taken in the Proposed Rule. For example, Reg.Guide 1.174 relies on the use of the Large Early Release Frequency (LERF) to determine which plant features may be permanently modified. However, the SNL SOARCA results show that there would be no large early releases, i.e., LERF =0 and the RBR report independently supports this. ***It would appear that all NRC guides that rely on a non-zero value of LERF should be reviewed for relevance. More generally, the very low offsite health consequences that are calculated for both accidents and terrorist events using SNL SOARCA and RBR technology should be reason enough to review the entire regulatory process to see where greater efficiencies could be obtained.***

There are many other regulatory areas that might be subject to modification based on the results that have come out of the SOARCA analyses. For example, the risk significance of mitigative safety systems, such as containment sprays which reduce the source term, is less than thought before. This is because source term mitigation would be largely accomplished by the aforementioned physical and chemical processes. This, in turn, might mean that in plant aging programs the emphasis on containment spray systems might be reduced to be commensurate with its lower risk significance.

3.6 Scope issues

3.6.1 Sequence truncation issues

Some comments offered here have their origins in the review process that the SNL SOARCA program is undergoing. However, because the SOARCA results are so important to emergency planning, these comments are presented here. One example of this is the issue of truncation in the sequences examined under the SOARCA program. As it turns out the RBR analysis offers some unique insights into resolving this truncation issue.

Interest has been expressed in examining where one draws "the line in the sand" in terms of which accident sequences could justifiably be considered as not significant factors in the public's overall health and safety, i.e., not risk significant. Historically, a sequence truncation level of 10^{-6}/reactor -year has been used for core melt accidents that do not bypass the containment and 10^{-7}/reactor-year for bypass events. Certainly lower truncation levels could be examined, however it is very unlikely that lower truncation levels for core melt accidents will affect the present conclusions about nuclear power plant risks or a modern approach to emergency planning.

There are multiple reasons why lower truncation levels are unlikely to affect the overall understanding of nuclear power plant risks or the development of emergency plans. First, if truncation levels were lowered by a factor of ten or more, this also lowers the frequency of all new sequences by a factor of ten or more. Even if larger consequences are found for these new sequences, their contribution to the overall risk may be small because of their smaller frequencies. Larger source terms, that might be uncovered at lower truncation levels, may not result in larger health consequences if the onset of the release was much later. An example of this can be extracted from TABLE 1 by comparing the Surry SGTR sequence to the Surry ISLOCA. The Surry ISLOCA has a frequency of $3(10)^{-8}$/RY and an iodine release fraction of about 0.10. The Surry SGTR has a frequency of $5(10)^{-7}$/RY and an iodine release fraction of about 0.01. So the ISLOCA sequence is about 17 times less frequent, but its source term is about ten times larger. This might be considered similar to looking at lower truncation levels for situations that have larger releases into the environment. However, neither of these sequences would produce early fatalities. In the case of the SGTR the source term is too small, well below 5% of the core inventory. In the ISLOCA case the onset time of ten hours is more than sufficient to evacuate everyone beyond the range of the early fatality risk, even with a very slow evacuation.

Since lower truncation levels are not likely to increase the early fatality risk attention turns to the latent fatality risk. The RBR analysis showed that source terms as large as the SBO source term (See Appendix B) would not produce latent fatalities beyond 3 to 4 miles for those people who have taken shelter and turned off ventilation systems. Inserting the SOARCA analyses ISLOCA source term into an RBR evacuation analysis would not result in any latent fatalities because there would be enough time to evacuate the downwind population out to the point where they could either take shelter and avoid latent effects or continue to evacuate and largely avoid latent effects. Inserting the SOARCA source term for a SGTR into an RBR analysis might result in some evacuees still within 3 to 4 miles from the site when the SGTR release began. However, the number of latent fatality consequences in this case would be considerable smaller than those calculated in the RBR report for a LOC release because the SGTR source term is about a tenth the size of the RBR LOC source term and the SGTR onset time is 3.5 hours versus 2 hours for the RBR LOC sequence. As shown in TABLE 3 just an additional 0.5 hours was sufficient to reduce the calculated mean number of latent fatalities from 114 to 82, yet the SGTR sequence would have an additional 1.5 hours and would be ten times smaller. This implies that the SGTR source term inserted into an RBR analysis should result in a near zero number of latent fatalities.

The most rapid release in the SOARCA analysis was for the SGTR. Even if a search for larger source terms at lower truncation levels identified a source term ten times larger, and reduced the onset of the release from 3.5 hours to 2.5 hours the consequences at the Indian Point site should not exceed about 82 latent fatalities, but a lower frequency than $5(10)^{-7}$/RY. Insights from the RBR report applied to the issue of truncation levels in the SOARCA program support the notion that searches of lower truncation levels are not likely to alter conclusions about the SOARCA results in a major way.

Finding larger source terms at lower truncation levels in an accident sequence may be difficult. Much larger source terms might require the discovery of a new mechanism that accelerated the core melt progression and/or decreased the source term removal processes within the reactor vessel and the containment or along the pathway from the reactor core to the environment in a bypass event. Apparently no such mechanisms were identified in all the experimental work that supports the SNL SOARCA program. In fact, the SNL SOARCA program concluded that previous postulated phenomenological causes of a prompt loss of containment integrity were not risk significant. Specifically, prompt containment failures due to in-vessel steam explosions are now considered negligible/highly improbable. Similarly, prompt containment failure due to direct containment heating is also now considered negligible/highly improbable.

Many accident parameters would be unaffected by lower truncation levels. The inventory of radioactive material in the reactor is independent of the truncation level. This is also true of the mass and heat capacities of the materials within the reactor vessel, the amount of zirconium metal that might undergo metal-water reactions, the surface areas within the reactor vessel and containment upon which radioactive material might deposit during a core meltdown, the decay heat curve, melting points, the solubility of various iodine and cesium compounds, gravitational settling, and so forth. Because so many accident parameters are unaffected by the choice of truncation levels, the possibility of discovering new accident phenomena that might lead to larger releases is limited.

Of particular interest is the SOARCA analysis of Surry for the short station blackout scenario. Without any onsite or offsite electrical power and without a steam driven auxiliary feedwater pump there may not be any further equipment failures or operator errors that could be identified in a lower truncation analysis that could increase the size of the source term or the rapidity of the onset of a release of radioactive material. The very small source term calculated for the short blackout scenario implies that it was exclusively the chemical and physical processes acting within known structures (reactor vessel, piping, containment, etc.) that limited the releases to the environment (See TABLE 1). As stated in the paragraph above, unless there are reasons why these chemical and physical removal processes would not work or unless new chemical or physical processes are discovered, it seems improbable that major changes in the source term for the short blackout scenario for Surry would occur. Since this scenario does not rely on engineered safety features or operator actions to limit releases to the environment and since the discovery of new accident phenomena that lead to much larger source terms appears to be unlikely, it seems that the dominant risk effect of going to lower truncation levels would be their smaller accident frequencies.

Similar arguments apply to accident scenarios that bypass the containment building such as steam generator tube ruptures (STGRs). The Surry iodine source term for STGRs is about one percent of the reactor core's iodine inventory. This very limited release is achieved without engineered safety features and is the result of various natural processes that trap the iodine along its complex pathway from the reactor fuel to the environment. Another important Surry <u>bypass</u> scenario is the very rare Interfacing Systems Loss of Coolant Accident (ISLOCA) which appears to have a more direct path to the environment than the SGTR pathway. Even so, the iodine that might be released to the environment has been calculated to be about 10% of the core's inventory of iodine. Some 90% of the iodine is removed by natural process without the aid of engineered safety features in the ISLOCA sequence.

It appears that present nuclear power plants act much like complex filters. If the pathway of the radioactive material once contained in the fuel bypasses the containment on its way to the environment, the plant would passively filter out about 90% to 99% of the iodine and cesium core inventory. If the pathway of such radioactive material from the reactor to the environment passes through the containment, about 99% or more of the iodine and cesium core inventory, provided the containment's integrity is maintained for several hours. Those accident scenarios that have radioactive material that travels through the containment building, may experience even smaller source terms if mitigative engineered safety features, such as containment sprays, are operational.

The consequence analyses in the RBR report sheds further light on this truncation issue. Even if some mechanism was identified that could produce a larger source term, it is unlikely that this would materially affect the calculated early fatality risk. Most sites have very few people (no receivers) within a mile of a potential point of release and therefore have a near zero early fatality risk regardless of the size of the source term or the frequency of a scenario. Even those sites that have people within the range of the early fatality risk, but who would have been evacuated beyond this range prior to the onset of a release of radioactive material, would not see an increase in the early fatality consequences even with a larger source term because of the technology of co-existence. Evidence of this appears in the RBR report where the larger, but more delayed, source term of the station blackout (SBO) sequence had lower early fatality consequences than the earlier, but smaller, loss of coolant (LOC) sequence. (See TABLEs 2 and 3) This is the case because there was very limited co-existence for the SBO sequence. The RBR analysis calculated that most people would have been evacuated beyond the range of the early fatality risk at the time of the onset of the SBO sequence. TABLE A-5 of the RBR report for the SBO and LOC source term characteristics is reproduced in this report as Appendix B.

Even if some people were still within the range of the early fatality risk at the time of the onset of a release, they would have to be in a highly concentrated narrow plume to reach exposure levels that might result in an early fatality. Suppose that the frequency of weather conditions that would correspond to producing such narrow plumes was 0.1/year. When the accident release frequency is multiplied by the weather frequency of having such a narrow plume along an evacuation pathway, this results in overall frequencies equal that of lowering the truncation level by a factor of ten. Searching the SOARCA analyses for important events that might have been screened out by the choice of a cut-off value is limited to examinations of the core melt frequency and the containment release frequency, i.e., a level-1, level-2 domain exercise. However, once one begins to think in terms of consequence analyses, i.e., level 3 analyses, then there are two frequencies that must be multiplied together to get a statement of risk. These are the in-plant derived frequency of a release and the site frequency of adverse weather conditions. In effect, level 3 analyses build into them aspects of lower truncation analyses in that overall frequencies are lower.

Based on the above, it does not look to be fruitful to explore lower truncation levels for the classes of accidents analyzed in the SOARCA program; core melt accidents with an initially intact containment and bypass accidents. Neither important changes in the calculated risk nor in the development of emergency planning technology are apt to change due to exploring lower truncation levels. Similar conclusions can be reached for latent fatality risks. Only if one went beyond the scope of the SOARCA program, such as postulating terrorist attacks that immediately breached the containment or reduced the source term removal processes in containment bypass events, would a non-zero early fatality consequence be possible. Yet this was exactly the type of analysis performed for the RBR report and the health consequences due to such sequences were calculated to be very small.

Instead of looking for new insights at lower truncation levels it might be more effective to examine events outside of the scope of the SOARCA program, as discussed in Section 3.5.3. Simply stated we should "dig wider, not deeper"..

3.6.2 LNT truncation issues

The SOARCA program explored the sensitivity of the individual latent cancer fatality risk within the EPZ as a function of the assumed threshold, including no threshold corresponding to the present LNT theory. The RBR analysis conservatively did not assume any latent fatality threshold. Further, small thresholds have little to no effect on the calculated number of latent cancer fatalities in the EPZ due to exposure during the plume passage time period.

Regardless of if or how dose thresholds are treated in risk analyses, the overriding point is that all calculated radiologically caused latent fatalities from releases from nuclear power plants are but a very small fraction of background values, are far less likely to occur compared to natural causes, and would be too small to be detectable from epidemiological studies. A review of the World Health Organization's 20 year retrospective on the Chernobyl accident supports the conclusion that long term health effects from that accident are far less serious than earlier predictions and indistinguishable from background cancer rates (Reference 9). The RBR report makes this point as well. As shown in TABLE 3, the mean number of latent fatality cancers from a terrorist caused LOC release at Indian Point is 114 people compared to an expected background cancer fatalities in the EPZ population of 80,711. Not only is the ratio of the consequences of terrorist causes of latent cancer fatalities to background causes small, 114/80711 =.0014, the frequency ratio of successful terrorist events on a nuclear power plant to the frequency of background cancer fatalities (frequency ~1.0) is very small. There has never been a successful terrorist attack on a nuclear power plant. Even though the frequency of such an event is unknown, it is clearly smaller than the background frequency of ~1.0. With both consequences and frequencies of successful terrorist events causing cancer fatalities smaller than background values, the risk of contracting cancer from radiological releases from nuclear power plants is exceedingly small.

A latent cancer fatality threshold, while not significant for emergency planning, could be important when calculating the number of latent fatality cancers out to great distances due to low level exposures. Most calculated latent fatality cancers are due to having many people at significant distances exposed to very small doses accumulated over long periods of time. Thresholds like those reviewed in the SOARCA program would reduce the number of calculated latent fatalities. Further, accounting for changing wind directions during a prolonged release of radioactive material would further lower the number calculated latent fatalities if there were an assumed threshold. Changing wind directions would spread the radioactive material out and lower its average concentration. This, in turn, would cause more of the population dose to fall below the threshold value.

3.6.3 Lesser acts of terrorism

The magnitude of the source terms released into the environment is a function of the opportunities that various chemical and physical processes have to reduce the source term. Event sequences where there is a slow overpressurization of the containment provide long time periods for gravitational settling, opportunities for soluble compounds to be trapped in water pools formed within the containment and opportunities for fission products to adhere to the many surfaces within the reactor vessel, piping, and containment. Therefore such sequences typically have very small source terms. This is evident in the source terms in the SOARCA analyses of unmitigated station blackout sequences. As shown in TABLE 1 the iodine release fraction for such sequences is less than one percent.

Two initiating events that can lead to station blackout sequences are seismic events and fires within the nuclear plant. For such initiating events, the unmitigated iodine source term is very small, as noted above. This means that if an act of terrorism or sabotage, such as starting fires in critical locations, the offsite radiological consequences would, at worst, be very limited. It can be deduced from this observation that even if a terrorist attack was successful in damaging a nuclear power plant, **in many situations it would have a minimal radiological impact offsite.** In order to have a larger offsite radiological effect there would have to be a prompt loss of containment integrity combined with a core melt sequence. This is precisely what was analyzed in the RBR report, with the finding that the calculated health consequences were still quite limited.

3.6.4 Aircraft crashes

Intentional aircraft crashes are of special interest because of the 9/11 attack on the World Trade Center. One of the planes that flew into the World Trade Center came down the Hudson Valley, close to Indian Point. Documents have been recovered from terrorist groups that identify nuclear plants as potential targets of interest.

The RBR report is useful in providing insights on the consequences of assumed successful terrorist attacks using large aircraft that might breach the containment and initiate a core melt sequence. No attempt is made here to estimate the probability of such an event.

The assumptions used in the RBR analysis were, in one major respect, more conservative than assuming that an aircraft crash was the cause of breaching the containment and initiating a core melt sequence. This is because no credit was taken for additional plume heating due to the explosion and subsequent burning of jet fuel. Plume heating causes the released radioactive material to rise and to become diluted, thereby significantly lowering the possibility of causing an early fatality. This plume heating dilution would also decrease the calculated latent risks if latent fatality thresholds are considered and would also lower calculated economic losses because more areas would be within the EPA's reoccupation dose limits.

About 92 MW-hrs of energy could be contained in the jet fuel in the type of aircraft that struck the World Trade Center (Reference 10). The energy of the jet fuel greatly exceeds typical plume internal energies from nuclear accidents. Based on crash tests conducted by Sandia National Laboratory a fireball would result from air crashes above speeds of 135 m.p.h.(Reference 11). It was observed that significant fires were initiated by the air crashes at the World Trade Center and at the Pentagon. "The impact of fuel-laden planes caused explosions and large long-lasting fires. Those explosions and fires destroyed a portion of the Pentagon in northern Virginia and caused the collapse of the World Trade Center towers and nearby buildings in New York City." (Reference 11). Because the RBR analyses did not include additional plume heating from burning jet fuel, its analysis is conservative relative to analyzing the health effects of an aircraft crash at Indian Point.

Another aspect of terrorist attacks using aircraft is that a large highjacked aircraft would today be identified very rapidly, likely before it could crash into any facility. This could provide some time to initiate a precautionary evacuation. Further, should there be a crash, the resultant explosion would alert the surrounding area, thereby supplementing existing emergency alert systems.

The Chernobyl accident was an important demonstration of the effects of plume heating. The reactor power excursion and the subsequent burning of the core's graphite contributed to the plume's internal energy and the plume was lofted to considerable heights. At Chernobyl there were no early fatalities among the general public, even though they did not evacuate. Radiation measurements made during the accident did not indicate high dose rates in the vicinity of the public. Because the radioactive material was lofted high above the public there was no co-existence. Some 28 people did become early fatalities at Chernobyl. However, these fatalities were limited to firemen who went on site and a person in a helicopter that flew through the rising plume.

The analysis of the potential radiological health consequences from hypothetical aircraft threats should include the effects of plume heating. Such analyses and/or the location of a nuclear plant in a low population zone might preclude the need for special plant features to offset the effects of potential aircraft crashes.

3.6.5 Further thoughts on other types of accidents

As stated above, the SOARCA program examined a class of accidents: core melt accidents with an initially intact containment and by-pass accidents. ***Other types of accidents/incidents outside the scope of the SOARCA effort are possible and should be examined to see if they could possibly affect emergency planning.*** Among these other types are releases from a spent fuel pool that recently had reactor fuel loaded into it during a refueling outage, shutdown accidents with an open containment, reactivity excursions of sufficient magnitude to cause a release of radioactive material, and terrorist events, including aircraft crashes/missiles as discussed above. Some further thoughts are provided below on these other types of accidents.

Under usual conditions the iodine and tellurium levels in a spent fuel pool are very small. Iodine and tellurium are the dominant contributors to early health effects. The major concern about fires in spent fuel pools is the release of radioactive cesium which some people believe would cause extensive land contamination and economic losses.(Reference 11). These concerns led to a major review of this issue by the National Academy of Sciences who recommended simple, relatively low cost mitigative actions like more optimum spent fuel configurations in the pools. It was also shown that initial calculations of offsite health and economic consequences were considerable over estimated. (Reference 12). It takes several hours after a pool is drained before a spent fuel fire might commence, thereby providing time to initiate an emergency response and time to attempt to cool the spent fuel by spraying water on it. In the event of a drained spent fuel pool and subsequent fire under usual conditions, a simple sheltering emergency response would be entirely adequate. However there can be times when a reactor core is temporarily loaded into the spent fuel pool during a refueling outage, raising the iodine and tellurium inventory in the pool during the outage. Fires in spent fuel pools would likely result in heated plumes that would reduce the possibility of causing an early fatality. If the cause of the draining of the fuel was from an aircraft crash, burning jet fuel could also add to plume heating. TABLE 4 provides recommended emergency responses for times when the fuel from the reactor core is temporarily loaded into the pool and for the majority of the time when such hot fuel is not in the pool.

It is anticipated that the power level during a shutdown event would be too low to cause a significant release, even with an open containment. Further, iodine levels would have decayed to smaller amounts than at full power conditions. An emergency response of sheltering in the inner two miles from the point of release should be adequate for shutdown events with an open containment.

Reactivity excursions in PWRs are very unlikely. While very unlikely, BWRs have a greater potential for reactivity excursions than PWRs under normal power operation. It would probably be sufficient to just re-examine ATWS events in BWRs with MARK-I containments to assure that sufficient safety relief capability exists to preclude reactivity excursions.

Insights on reactivity excursions may be gained from reviewing the accident at Chernobyl where prompt criticality was apparently obtained. It has been reported that the power excursion in the Chernobyl reactor increased its power level 100 fold in about four seconds. This was followed by a chemical reaction where the hot graphite became exposed to air and then caught fire. In addition, the Chernobyl plant had a weak confinement system, not a containment system. In spite of all these factors, it is estimated that the core fractions of iodine and cesium released from Chernobyl were 0.60 and 0.40, respectively.(Reference 9). The SST-1 core release fractions used in the Sandia Siting Study were 0.45 and 0.67 for iodine and cesium, respectively. In other words the old SST-1 estimate of the source term was rather similar to that of Chernobyl's in spite of originating from a far less energetic event and having a far superior containment. This comparison with the Chernobyl accident lends further support to the SOARCA conclusion that the source terms used in the 1982 Sandia Siting Report were far too large.

There may be other types of security related events not listed here. It is recommended that a classified review of security issues take place to see if additional types of terrorist related events should be added to TABLE 4. If so, their source terms should be calculated and a preferred emergency response should be selected.

3.6.6 Emergency response scope issues

In addition to looking for special situations through lower truncation levels and through other types of accidents within nuclear plants, special situations should also be looked for off site in the emergency response. In general, people who participate in the emergency response would be at very low risks. It is those that do not participate that bear the greatest chance of receiving exposure to radiation. One area that warrants close examination is in the transportation dependent population. Lack of adequate transportation was a critical issue during the emergency response to Hurricane Katrina. ***Provisions should be made to assist those who live close to a nuclear site and do not have access to transportation.*** One possible solution is to encourage such transportation dependent people to congregate at nearby shelters where they would later be picked up by buses dedicated to this specific purpose. Shelters in large buildings and apartment houses would be preferred in that their shielding characteristics are usually superior. It may be most efficient to send local government personnel to these in-close shelters to make sure that they are open and then to assist people while they are waiting for a bus to pick them up.

As shown in TABLE 4, many emergency responses would encourage a large fraction of the EPZ population to take shelter. Some shelters are not as effective as others, such as sheltering in a trailer. ***Emergency response personnel should be made aware that sheltered people in trailers may have to be relocated if the measured dose rate level outside of these trailers is too high.*** Some EPZs have park areas where there are few, if any, areas to take shelter and people hiking on trails may not be listening for sirens. Nearby waterways may have people out in the open during an emergency. Emergency plans should take these offsite special situations into account.

In addition to evacuation in a vehicle, it would be beneficial to have dedicated pedestrian evacuation routes from the plant fence line out to three miles or so from a potential point of release. ***The end point of these routes should be a sheltered area where people could be picked up by bus and where provisions have been made to have these shelters open during emergency conditions.***

On the subject of sheltering, it should be determined if emergency instructions for sheltered people should include advice to turn off air circulation vents and other sources of air infiltration so that the inhalation dose is minimized. This advice may vary according to the distance from the plant.

3.6.7 Protective action guides (PAGs)

Page 1-1 of EPA 400-R-92-001 (Reference 13) provides very important guidance on balancing risks: "The decision to advise members of the public to take action to protect themselves from radiation from a nuclear incident involves a complex judgement in which the risk avoided by the protective action must be weighed in the context of the risks involved in taking the action". Note that this statement about balancing risks is not confined to just balancing one radiological risk against another radiological risk. Chairman Jaczko also spoke of this in his April 30, 2007 presentation "Wouldn't it be better if you had the flexibility to look at all the hazards your communities face and put the risk from a rural nuclear power plant with a small neighboring population in its proper context?".

Unfortunately the wisdom in this portion of EPA 400-R-92-001 has not always been appreciated. Some have interpreted the implementation of PAGs as a requirement to avoid an exposure as small as only one rem. The James Lee Witt (Reference 14) report talks of outrunning a one rem exposure. The Witt report states that "evacuation is recommended when exposure to the public is expected to exceed 1 rem". The Witt report assumed a "quick breaking release" of radioactive material into the environment. However, earlier source term analyses like those in WASH-1400, NUREG/CR-2239, NUREG-1150, the recent SOARCA source term analyses and the source terms used in the RBR report do not support Witt's concept of a "quick breaking release". Assuming a "quick breaking release" implies a very large source term and this is inconsistent with the experimental results utilized in the SOARCA analysis and elsewhere. Hypothetical prompt large releases of the type that Witt talks about could produce a 1 rem dose out to a considerable distance. It is understandable that Witt would consider evacuation of the large Indian Point population as impossible if he thought that it would be necessary to outrun this very small dose out to great distances The PAG concept has generated confusion in the emergency planning arena. PAGs are set at far too low a level and evacuating from such a low dose is an inappropriate emergency response.

One observation based on traffic calculations supporting the RBR report was that the larger the number of people that evacuate, the slower the evacuation. This is consistent with common sense. If PAGs are interpreted that they should be implemented on an <u>individual</u> basis where each person seeks to avoid very low exposures, like one rem, by evacuating, this almost certainly will lead to an over-evacuation. The small dose saving that some individuals might achieve by evacuating when they should be taking shelter might cause the evacuation of people nearer the site to be slowed down, resulting in this inner group receiving higher exposures. This likely would increase the overall exposure within the EPZ. ***Application of PAGs, if at all, should be implemented on a group basis rather than on an individual basis to achieve the lowest overall exposure that is practical.*** Stated differently, applying the principle of ALARA,"As low as reasonably achievable" should be directed towards minimizing group exposure, not individual exposure. This group approach to implementing the ALARA principle is an especially important consideration for high population sites.

There are also reasons to balance different risks, not all of which are radiological. There were significant psychological health consequences from the Chernobyl accident. Fear of being exposed to radiation led to a large number of unnecessary abortions, increased alcoholism, and depression. If people are evacuated needlessly this may cause some people to believe that they have received a significant exposure to radiation. Over-evacuation can overwhelm reception centers, cause people to seek medical help they actually don't need, increase the chances that different family members will become separated during the evacuation, especially if children in the same family attend different schools. People who have been evacuated unnecessarily from their homes may refuse, out of fear, to return to their homes. It is instructive that displaced people following Hurricane Katrina faced many hardships. Therefore there are both radiological and non-radiological reasons not to over-evacuate people inside the EPZ.

3.7 Important boundaries

3.7.1 The most fundamental boundary

It is important to convey to the public that their protection in the event of a release of radioactive material from a nuclear power plant does not end at the edge of the Emergency Planning Zone (EPZ). Within the EPZ public protection is accomplished by a specific approved plan that is periodically tested. Inside the EPZ the cognizant agencies establish specific requirements for emergency responses. Outside of the EPZ boundary, planned actions would give way to ad hoc actions that are to be implemented by local emergency responders based on local measurements of radiation levels and other conditions such as the weather, time of day, and if the site is under hostile attack.

Ad hoc actions also protect the public. The justification for the ad hoc region is that dose rates are very low in this area, there is plenty of time to take protective actions, the recommended protective actions, if any, are simple to execute and in most cases would just be a recommendation to go indoors, or possibly to go indoors and seek shelter, as in a basement. People in the ad hoc area who are not downwind from a damaged nuclear plant would not be at radiological risk. Further, many of the resources applied to protect people within the EPZ are also available to protect people beyond the EPZ in the ad hoc region. Among the resources available to people in the ad hoc region is information from emergency broadcasts on plant conditions and the results from radiation level measurements made by emergency responders already in the field. The ad hoc region would be far from the area where early health effects might occur from high levels of exposure, assuming a successful terrorist attack.

Dividing protected areas into planned and ad hoc regions is common practice for other hazards. ***In any case, members of the public who reside in the ad hoc region should be assured that they have not been forgotten and would be protected in the event of an emergency.*** Ad hoc protection is also appropriate at these greater distances from the site because the exact evolution of an accident and the meteorology of the surrounding area and other variables would not be known until the accident occurs. Responses in the ad hoc region would be tailored to the actual event. Whereas the federal government establishes requirements and runs drills/inspections within the EPZ, it can offer, a priori, general guidance to local emergency responders operating in the ad hoc region. This guidance might be in the form of how to convert local radiation measurements made by the emergency responders into terms that the public is familiar with, such as relating doses[4] to typical medical radiation exposures and conveying these readily understood exposures to the public. Once expressed in everyday terms, the public is apt to be less fearful and more willing to carry out instructions issued by government officials, such as taking shelter instead of evacuating.

Present EPZ boundaries, nominally with a radius of ten miles, were based on judgements made many years ago that related to the conditional probability of causing an early fatality versus distance, assuming a very large release of radioactive material. However, if either modern source terms or RBR results were used in this old process, the resultant size of the EPZ would be between zero and one mile. Such small EPZs would be inconsistent with NRC's defense-in-depth safety philosophy and would not capture the importance of the latent fatality risk which continues indefinitely unless there is a threshold cut-off. Therefore as part of modernizing emergency planning it is both necessary and technically justifiable to establish the size of the EPZ based on the latent fatality risk distribution.

It is recommended that a conservative approach be taken when establishing the size of the EPZ. A conservative approach would tie together modern technology, such as source terms and release frequencies, with the latent fatality safety goal. Two possibilities exist. In the first possibility the radius of the EPZ would be established on the basis of accidental releases. In the second case the size of the EPZ would be based on intentional releases caused by assumed successful terrorist attacks. It is recommended that the following definition which would apply to both accidents and terrorist events be accepted:

The radius of the EPZ should be that distance where the average latent fatality risk to people at that radius from a release of radioactive material would not be more than one part in a thousand per year compared to background cancer fatality risks, even if they used a normal activities response for 24 hours after the onset of the release and assuming 95th percentile weather conditions.

A normal activity type response is equivalent to a person acting as if he/she was completely unaware of the accident or terrorist attack. See TABLE A-6 of the RBR report for representative shielding factors for a normal activities response.

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[4] A chart on ionizing dose ranges has been developed by the Department of Energy. Go to "Orders of Magnitude", revised March, 2008, http://www.science.doe.gov/ober/
Example: A 2 minute fluoroscopy scan (barium contrast G.I.) has an 8.5 rem exposure.

The Proposed Rule does not address the size of the EPZ, but it should.

For unintended accidents both source terms and release frequencies have been calculated for each accident sequence. It is therefore possible to determine the radius of the EPZ that meets the above latent fatality risk limit for each scenario and then select the largest of these radii. However, if this were done the largest of these radii would still be quite short, about a mile. The data in TABLE 1 for accidents at Surry and the data in TABLE 6-S of the RBR report can be used to show this. Use was made of the LOC data in TABLE 6-S of the RBR report at the 95% weather condition. This table was chosen because the RBR LOC source term is close to the magnitude of the Surry source term for an ISLOCA. TABLE 6-S is based on 24 hours of a normal activities response.

It was concluded that the one mile distance required to meet the proposed latent fatality based EPZ size using accident conditions was too short and that the size of the EPZ should be based on the consequences from a postulated terrorist event similar to the SBO sequence described in the RBR report. Since the absolute frequency of such an event is unknown, the conditional frequency methodology described in section 9.3.1 of the RBR report, and TABLE 6-T for the SBO sequence was used. The conditional probability of terrorist success would be estimated by plant security analyses. If plant security analyses indicate that the conditional frequency of a successful terrorist attack that could lead to a source term of the magnitude of the RBR SBO source term, the EPZ radius needed to meet the recommended latent fatality criterion would be about 3 miles if the calculated terrorist success probability based on physical security analyses was around one part in ten thousand. If the calculated terrorist success probability was about four in ten thousand, then a 5 mile EPZ would be necessary and a physical security success probability of one in a thousand leads to an EPZ about 7.5 miles in radius, based on the 24 hour normal activities response described above. See Figure 9-C in the RBR report.

This approach to setting the size of the EPZ is very conservative. These EPZ radii would be far beyond the range of the early fatality risk, if any, even for assumed successful terrorist attacks and, conservatively, are based on the 95 percentile weather condition. It is very unlikely that an individual at this radius would remain in a normal activities mode for 24 hours. After all, this is the innermost area of the ad hoc region and emergency responders would be making radiation measurements and encouraging downwind people to take shelter until further notice is given. Additional information would be broadcast over the media. In establishing this radius, all release sequences would be examined and the one that results in the largest EPZ radius that meets the proposed definition, above, would be utilized. Therefore this radius is conservative for all sequences except the most limiting one.Other individuals in the ad hoc region who are further from the point of release than the EPZ radius, would have even larger safety margins. This is because the calculated dose rate decreases with distance. In the SBO case, a person in the 3-4 mile annulus would have about a third of the exposure of a person in the 2-3 mile annulus. Further, the conditional frequency of a successful terrorist event is assumed. The absolute frequency, while unknown, is smaller than the conditional frequency.

There are other advantages to this approach. The analysis is independent of population density. It is also independent of the time of the onset of the release of radioactive material since the "24 hour clock" does not start until there is an onset of a release. The type of emergency response is uniform at all nuclear sites and simply is "normal activities". With such an assumed response there is no need to perform traffic analyses, since people would be assumed to remain at the same locations for 24 hours. Different meteorological data at different sites are not expected to be a major consideration.

In summary, a very conservative approach to determining the size of the EPZ is to take the terrorist related scenario that has the largest source term, use an unlikely weather condition, use the conditional frequency of success this terrorist attack which is larger than the absolute frequency, and assume that for 24 hours the receiver at this radius is unaware of the attack and utilizes a normal activites response, yet does not have his/her incremental latent fatality risk increase by more than one part in a thousand compared to background natural cancer risks. The ad hoc protection area would have an inner radius equal to this EPZ radius.

Section 3.3.1, An integrated regulatory process, explains that a new capability now exists because of the ability to equate quantified offsite emergency planning actions to quantified actions internal to the nuclear plant. In this section the relationship between the size of the EPZ and plant physical security was explained. These two concepts can be merged which would result in a win-win situation.

Suppose that one of the goals of the Proposed Rule were to establish the size of EPZs based on modern, defensible technology. Further, suppose that it is desirable from a regulatory point of view to have the same EPZ radius at each nuclear site. For the sake of argument, assume that this radius was four miles. This would be attractive to utilities in that an emergency planning zone with a four mile radius would have just 16 percent of the area of the present 10 mile EPZ. It could also be attractive to local communities as it would reduce their costs and demands on their resources. Federal agencies could focus better on this smaller sized EPZ and this should benefit safety.

In order to technically justify this four mile radius, using the process described in this section, the frequency of a terrorist-caused release of radioactive material of the magnitude of the RBR report's SBO source term would have to be smaller than about $2\ (10)^{-4}$/RY, based on RBR figure 9-C. Thus, setting a uniform EPZ size essentially sets a uniform physical security frequency requirement for all plants if all used the same sized source term.

Now in order for a nuclear utility to justify a four mile EPZ, it would have to demonstrate that the nuclear plant's physical security frequency level was at or below $2\ (10)^{-4}$/RY, assuming an SBO sized release. If a plant's physical security frequency exceeded $2\ (10)^{-4}$/RY, compensatory steps would have to be taken which reduced the release frequency and/or source term. Compensatory steps like portable emergency electric power supplies, alternative means to activate a containment spray system, external water sprays at the expected point of release and the like, might be considered. This additional capability would also lower the offsite health and economic risks for a whole spectrum of less challenging sequences, be they from accidents or terrorist events, The benefit of this additional capability to reduce accidental releases would be small because existing risks are already so small. Note that implementing this physical security based approach could require that different physical security preventative and mitigative actions might be subjected to a greater degree of quantification than they are now. Applying PRA techniques to implementing physical security measures has significant benefits all on its own, not the least of which would be a reduction in the possibility that some plant change made to improve physical security didn't create a situation that normal plant safety is degraded. It is expected that utility PRA people would work closely with plant security personnel.

Simply stated, this new quantification capability produces many benefits for different stakeholders. It ties together actions within the nuclear plant to offsite emergency planning. It places the analysis of unintended accidents and hostile terrorist actions on a consistent basis. It connects plant physical security capabilities/requirements with traditional safety policies, such as the health safety goals. One of the central purposes of the Proposed Rule is to integrate emergency planning with plant security issues. This process of establishing the EPZ radius based on physical security capabilities and using plant equipment and procedures to assure that these physical security capabilities will achieve specific performance levels is completely consistent with that purpose of the Proposed Rule. Further using the same PRA techniques for plant security as is used for safety analyses would bring a higher level of rigor to implementing physical security while reducing the chance of unintended safety risks introduced by implementing physical security measures. This totality of interconnected and quantified regulatory actions becomes the new regulatory emergency planning paradigm Chairman Jaczko spoke of and it would apply to all present and future nuclear plants.

3.7.2 Other boundaries within the EPZ

It is recommended that the EPZ be subdivided into four regions. These regions consist of an inner circle of two miles, a wedge area, a downwind sheltering area and an unaffected area. The preferred response for the unaffected area would be to go indoors and listen to emergency broadcasts for further instructions. It is possible that wind shifts might cause some of the initially unaffected area to become downwind and, if so, the newly affected area should then take shelter, as directed by emergency broadcasts or other alerting media.

For the larger postulated releases from terrorist events where the site is not under armed attack and roads are not blocked, the most effective emergency response would be a mix of evacuation followed by downwind sheltering out to the EPZ boundary. This mix of evacuation and sheltering is particularly important at high population sites like Indian Point because an all-evacuation response would result in a slower evacuation speed and larger health consequences.

Terrorist attack type T3 (See TABLE 4) is representative of a situation where some terrorist action breaches the containment and initiates a core melt sequence soon thereafter. This type of terrorist event was investigated in the RBR report. Consistent with present practice today, it is recommended that prompt evacuation be the protective action taken for the innermost two miles from the potential point of release. Since this prompt evacuation is to cover 360 degrees, it is independent of the wind direction. Prompt evacuation out to two miles accomplishes several things. If source terms are larger than presently calculated and/or onsets of releases occur sooner than presently calculated or if there are unfavorable weather conditions, a prompt evacuation of the inner two miles should be more than enough to encompass uncertainties in the calculation of the early health effects risks. An evacuation out to two miles also is effective in reducing the latent fatality risk. The highest individual latent fatality risk is in the area closest to the point of release.

Beyond two miles it is unnecessary and even undesirable to evacuate a full 360 degrees for a T3 event. Prompt evacuation of the inner two mile area should be supplemented by a downwind wedge prompt evacuation area, thereby forming a "keyhole" shape consistent with keyhole approach used today in emergency plans. It is possible to optimize the size and shape of this wedge area by making it wider than three sectors. The inner radius of this wedge area would be two miles and the outer radius would be the point at which the preferred protective action for downwind people changes from evacuation to sheltering. ***This switch-over from evacuation to sheltering should occur at the point where sheltering would be as effective as evacuation in limiting the latent fatality risks or where the overall exposure begins to increase because larger evacuations result in lower evacuation speeds.*** This latter definition of the outer radius of the wedge area is equivalent to the radius at which overall exposure is at a minimum for the scenario that is most significant, such as the LOC scenario in the RBR analysis.The wedge area also is a function of the angle subtended by the wedge. In order to adjust for possible wind shifts between the time when a General Emergency is declared and the time at which the onset of a release is reached, site meteorological data need to be examined. ***The angle selected for the wedge area should be wide enough so that there is a high probability that the wind direction would still be within the wedge area by the time that evacuation of the inner two miles is completed.*** This angular information needs to be communicated to the emergency response team and the public at or before the time at which evacuation begins. Present power plants have the capability to project wedge areas on their computer screens. These projected areas would vary as the wind direction at the site varied. Note that for events that would evolve slowly the direction of the wind is likely to change a number of times prior to any release of radioactive material. TABLE 4 provides some guidance on when to issue an emergency warning. The direction of the wind at the time when the warning to evacuate is given should be the direction of the centerline of the wedge area.

People in the downwind sheltering area should have a near zero latent fatality risk during plume passage, assuming that air infiltration is minimized. The angle selected for the wedge area would also be used to define the angle of the downwind sheltering area.The inner radius of the sheltered area is the same as the outer radius of the wedge area. The outer radius of the downwind sheltering area is the same as the EPZ radius.

3.8 Emergency responses for PWRs

TABLE 4 summarizes recommended emergency responses for both terrorist and accidental events for PWRs. A similar table can be drafted for BWRs. This table takes into consideration that different release scenarios can have different sized source terms where larger potential source terms are best responded to by prompt localized evacuations and further out downwind sheltering. Smaller potential source terms may adequately be responded to by just sheltering or just staying indoors if further away. People beyond two miles and not in the wedge area or the downwind area need only stay indoors and listen to emergency broadcasts. Regardless of the potential magnitude of a source term, the radius of the EPZ would be the same and set by the method described in section 3.7.1 with an innermost two mile radius circular area, measured from a potential point of release. The need for a prompt evacuation wedge area is limited to scenarios where a large, early release of radioactive material is possible. This table also takes into consideration that there is a large variation in the onset times of different release scenarios. Relatively early releases call for prompt responses. Some scenarios could take a very long time before there might be a release to the environment. In such cases it might not be reasonable to assume that people would shelter or even remain indoors during the many hours prior to the onset of a release. Further, in these slowly evolving scenarios, releases may never occur if plant recovery actions are successful. In addition, wind directions are likely to change during these slowly developing scenarios. Ordering sheltering in a downwind area too soon may result in a situation that the wind direction would have shifted by the time of the onset of the release of radioactive material. This would then require that a different downwind area should take shelter. Therefore it may be necessary to issue more than one emergency action public announcements prior to the onset of a release where the first announcement would mainly inform the public of the ongoing situation and advise them to continue to listen for updates. If the scenario looks like it will result in a release of radioactive material, then the need to take more protective actions, such as sheltering, would be announced. The information generated by the SOARCA effort on source term magnitudes and on the times of onsets of releases is most useful in these circumstances.

A situation where a large aircraft has been hijacked some distance from a nuclear site and it is uncertain if the local nuclear plant might be its target, calls for a different type of emergency response. In such a situation it would be prudent to order a precautionary evacuation of the inner one mile from a potential point of release. (See TABLE 4, event T1.) Precautionary evacuations of the inner one mile greatly reduces the potential for early radiological health effects as well as a good portion of the potential latent effects. If it turns out that there is no terrorist attack on the nuclear site, the limited evacuation of the inner one mile would have only inconvenienced those people who live very close to the site. However, should the possible terrorist attack turn into an actual one, then the evacuation of the remaining 1 to 2 mile annulus around the plant should proceed as well as prompt evacuation of the wedge area and downwind sheltering from that point, onward, as described in the response to a T3 situation provided that this terrorist attack has the potential to cause a prompt loss of containment integrity. Again this is a multistage emergency response and more than one alert would be need to be broadcasted. There are other circumstances where a precautionary evacuation of the inner one mile might be justified.

A number of possible terrorist scenarios involve the intentional loss of offsite power. If offsite power is lost and it is determined that this was caused locally, then this uncertain situation might be a forewarning of an attack on the site itself. Unless the site/EPZ then came under fire with a hostile attack, a precautionary evacuation of the inner one mile should be considered, i.e., a T1 response. If the loss of offsite power is accompanied by a loss of onsite power, such as from strategically located fires, but without a prompt loss of containment integrity, this is more serious than a T1 event and a T4 response should be used.

If there is an armed ground terrorist attack at the site of a nuclear plant or if the evacuation routes are blocked, people throughout the EPZ should take shelter until such time as a safe evacuation of the inner two miles might proceed. Here the concern is that with an armed attack at the reactor site members of the public could be in harm's way if they tried to evacuate. Therefore a sheltering response is recommended until this threat to evacuation is removed. See TABLE 4, event T2.

Table 4 Emergency Responses for PWRs

Type of event.	Response, inner two miles.	Response, wedge area, see section 3.7.2.	Response, downwind area, see section 3.7.2.	When to alert the public.
Terrorist Event	Terrorist Event	Terrorist Event	Terrorist Event	Terrorist Event
T1. Possible terrorist event, no plant damage yet.(Large hijacked airplane at a distance, loss of local offsite power, other warnings).	Precautionary evacuation of inner one mile. If attack occurs with possible prompt loss of containment integrity, same as T3 below. If containment is still intact, same response as T4.	Listen to emergency broadcasts. If attack occurs with possible prompt loss of containment integrity, same as T3 below. If containment is still intact, same response as T4.	Listen to emergency broadcasts. If attack occurs with possible prompt loss of containment integrity, same as T3 below. If containment is still intact, same response as T4.	As soon as terrorist situation is known. Multiple alerts needed.
T2. Armed terrorist attack within EPZ where evacuees might be in harm's way until threat has been removed.	Shelter until attack is subdued. If there has not been a loss of containment integrity continue to shelter, otherwise evacuate.	Shelter until attack is subdued. If there has not been a loss of containment integrity continue to shelter, otherwise evacuate.	Shelter downwind until attack is subdued. Downwind area has same angle as wedge area.	As soon as terrorist situation is known. Multiple alerts are necessary, first to take shelter, then to evacuate when armed attack is subdued, if containment integrity is lost.

T3. Terrorist attack initiated from offsite location, with possible/actual prompt loss of containment integrity. (Airplane crash, missile attack, etc.). No armed attack within EPZ.	Prompt evacuation of inner two miles.	Prompt evacuation of wedge area.	Shelter downwind, at same angle as wedge area.	Issue alert as soon as terrorist situation is known. Single alert likely.
T4. Less effective terrorist/ sabotage attack that does not cause a prompt failure of the containment, but initiates a station blackout. No armed attack within EPZ.	First, issue a warning to the public to listen to emergency broadcasts. Evacuate inner two miles before loss of containment integrity.	First, issue a warning to the public to listen to emergency broadcasts. If power is not restored before onset of a release, shelter in wedge area.	First, issue a warning to the public to listen to emergency broadcasts. If power is not restored before onset of a release, remain indoors downwind at same angle as wedge area.	First alert as soon as terrorist situation is known. Second alert, 25 hours minus ETE_{2miles}
T5. Spent fuel pool attack.	Shelter.	Remain indoors	Remain indoors.	As soon as terrorist situation is known.
T6. Spent fuel pool attack during refueling outage with hot fuel in pool. No armed attack within EPZ.	Prompt evacuation of inner two miles.	Prompt evacuation of wedge area.	Shelter downwind at same angle as wedge area.	Same as T3
T7. Other scenarios as identified through a review of plant security analyses.	Scenario dependent	Scenario dependent	Scenario dependent	Scenario dependent

Type of event	Response in inner one or two miles	Response in wedge area, see section 3.7.2	Response in downwind area, see section 3.7.2	When to alert the public
Unintended accident	Unintended accident	Unintended accident	Unintended accident	Unintended accident
A1. Steam generator tube rupture.	Evacuate inner two miles.	Shelter in wedge area.	Stay indoors at same angle as wedge area.	3.5 hours minus the ETE_{2miles}.
A2. Short station blackout.	Same as T4.	Same as T4.	Same as T4.	Same as T4.
A.3 Long station blackout (If operation of auxiliary feedwater system has been verified).	Same as T4.	Same as T4.	Same as T4.	45 hours minus ETE_{2miles} Multiple alerts likely.
A4. ISLOCA.	Listen to emergency broadcasts initially. Prompt evacuation of inner two miles once public alert alarm is sounded.	Listen to emergency broadcasts initially. Prompt evacuation of wedge area once public alert is sounded.	Shelter at same angle as wedge area.	10 hours minus the ETE_{2miles} Multiple alerts likely.
A5. Shutdown accident, open containment.	Shelter.	Remain indoors.	Remain indoors.	Soon after accident has been initiated.

3.9 Missing messages

The Final Rule on Emergency Planning would be of limited value unless it also addressed public acceptance, as encouraged by Chairman Jaczko. Yet none of the areas in the Proposed Rule addresses this critical need.

Much needs to be done to better inform the public about emergency planning and nuclear power plant risks in general. Some examples are given below:

1.

The public does not understand much about the differences between the early fatality and the latent fatality risks nor the ranges over which these might occur. The public needs to hear what they should do to be protected and how protective actions vary with distance and scenario. Often the imprecise view is that "radiation is radiation and it is bad". Some people opposed to nuclear power have quoted early fatality peak distances of 18 miles based on TABLE 2.6-2 of the Sandia Siting Report and then argue that this proves that the NRC's selection of a ten mile radius for the EPZ is therefore inadequate. They need to hear that the early fatality risk has a range of one mile or less. Others point to the very long distances calculated for 1 and 5 rem PAGs and seek very large EPZs. Still others point to the peak injury distance derived from the old Sandia Siting Report and conclude that a ten mile EPZ is too small. ***The results of the SOARCA program need to be communicated to the public and it should be made clear that these results replace those in the 1982 Sandia Siting Report.***

Such distance related challenges have been continuous for Indian Point. A committee of New York City's Council passed a resolution after the attack on the World Trade Center to shut down Indian Point because they had been (intentionally) misinformed that in the event of an accident or attack at Indian Point that all of New York City would have to be promptly evacuated, a near impossibility. Recently two New York State legislators sponsored bills to have the Indian Point EPZ expanded to 50 miles (enough to encompass New York City). No one has told the public or their elected officials that over-evacuation can increase exposures at high population sites.

With regard to the latent fatality risk, unless some cut-off is assumed, it has an indefinite range. This too has created public acceptance issues. Very few people in the public or their elected officials are aware of the strict NRC safety goals or that the risks from nuclear plants are very much smaller than these strict goals. Members of the public need to learn that latent fatality risks are tiny compared to natural background cancer risks. Members of the public have to hear that even the projected number of latent fatalities from the Chernobyl accident is far smaller than thought before, so much so that the World Health Organization says that they would be statistically undetectable compared to natural background cancer fatalities.

In the Final Rule, or in related documents, the NRC should address public acceptance issues. People want to know where they are safe, i.e., important distances, and what simple actions they should take at these locations. The public should be informed about the NRC's safety goals and how much margin a typical nuclear power plant has below these safety goals.

Among the major messages that need to be communicated to the public is that whether or not they live/work inside the EPZ or outside of it, they are protected. ***The public should be informed that the purpose of the EPZ boundary is to separate different forms of protection: areas within the EPZ use detailed planning and conduct emergency drills whereas areas outside the EPZ would receive ad hoc protection.*** The justifications for establishing the boundary between the detailed planning inner area and the ad hoc area beyond are given in section 3.7.1. and should be explained to the public.

2.

The NRC should communicate to the public and its elected officials that in developing Rule-making it has used the best science available. The NRC also should make clear to the public and other stakeholders that its development of the Final Rule was based on a broad scope: it reviewed a wide spectrum of nuclear and non-nuclear emergency situations including postulated acts of terrorism, it drew upon research conducted by our National Laboratories and around the world and it examined a wide range of possible radiation induced health effects from early health effects to long term health effects. People should hear that Rulemaking also reflects insights gained from a wide range of comments from many stakeholders and further, that, except for security restraints, all of the NRC analyses and submitted comments are available to the public for their review.

3.

The NRC should communicate that modern emergency planning technology has the ability to determine which actions are most effective in protecting the public and that it, the plant operators and the emergency responders concentrate their resources and emergency drills on these more effective actions. The NRC should inform the public that it has used the most modern technology to review the process of determining the size of the EPZ and the protective actions therein. Even more important, the public should be told that the majority of their protection comes from natural chemical, physical, and biological processes that do not require any action by plant operators and that these natural processes can not be defeated by terrorists, plant operator errors, or safety equipment failure.

4.

The NRC needs to inform the public that application of modern science leads to the conclusion that nuclear accidents are less likely than thought before, that only a small subset of nuclear accidents might result in a release of radioactive material, that these releases would be much weaker than thought before and would take longer to enter the environment. All of this modern science demonstrates, once more, that risks from nuclear plants are extremely small. Today what the public is hearing are the old 1982 Sandia Siting Report addendum extreme consequences and the figures from "Chernobyl on the Hudson" where the author claims that terrorist events directed at Indian Point could cause 44,000 early fatalities and 518,000 latent fatalities. The public and its elected officials should be informed that present nuclear plant designs and emergency planning can be very effective in limiting the health effects of terrorist attacks in the unlikely situation that they successfully attacked a nuclear power plant.

5.

The public and its elected officials should be informed that over-evacuation is undesirable because it causes evacuees to be slowed down and could actually result in small increases in health consequences for evacuees nearest the site. Therefore larger EPZs are undesirable from a public protection point of view.

6.

Although this is not directly tied to emergency planning, post- accident economic losses and the ability to return to one's home is important to many people, as shown in the quotation. Exaggerated losses, such as up to 2.1 trillion dollars, as proclaimed in "Chernobyl on the Hudson" have been put before the public with little factual information presented to counterbalance it. The SOARCA results could be used to update postulated economic losses and size of contaminated areas. Much like SOARCA's LNT sensitivity analysis, a similar analysis could be made on economic losses and contaminated areas as a function of the allowed EPA reoccupation dose. Presenting more realistic economic numbers could assist public acceptance of emergency planning.

4.0 Specific Comments

Many of the specific comments of the issues identified in the Proposed Rule are connected to the General Comments given in section 3.

1. Backup Means for Alert and Notification Systems

As shown in the results of the SOARCA program, calculated accident progressions are much slower than thought before. These slower accident progressions delay the onsets of releases to the environment, thereby providing more time to alert the public. As mentioned in TABLE 4, multiple warnings may have to be issued as the accident progression evolves. Further, as discussed before the health consequence significance of delays in notification is location and scenario dependent, with much more importance associated within two miles of the site whenever evacuation would be the preferred emergency response. ***When considering backup means to alert the public these factors of longer times until releases begin, smaller source terms and location differences should be considered.*** Because quantification of all of these factors is now possible, the resources dedicated to backup means should reflect the risk-reducing potential of such backup systems. One simple approach would be to concentrate backup systems in the inner two miles and depend on other means as the backup system at greater distances consistent with this very wired world that we now live in.

In the case of terrorist events, it is especially important to concentrate on the inner two miles. One recommended emergency response (See TABLE 4, T1) calls for a precautionary evacuation of the inner one mile. Such a recommendation lends further emphasis to concentrating backup alert and notification systems to the inner two miles.

2. On-Shift Collateral Duties

As mentioned earlier, the longer times before the onset of releases for accident conditions provides additional time to complete on-shift duties and this would reduce possible competition between such on-shift duties and emergency response duties. As in many of these issues in the Proposed Rule, the On-shift Collateral Duties issue is more important in hypothetical terrorist situations where less time may be available than in accident conditions. ***The NRC, with Sandia Labs support, should address the timing issue by analyzing hypothetical terrorist scenarios as described in TABLE 4.*** Such analyses would help sort out which on-shift duties might interfere with emergency responses.

3. Decreases in Effectiveness

This issue lends itself to the quantification, as mentioned before. For example, if some change occurred which caused a delay in the issuance of an important alert, the health effects of such a delay could be quantified. Since present capabilities permit the quantification of virtually every emergency response, this would help to focus on areas where decreases in effectiveness would be more important and, if appropriate, to levy fines or other corrective actions where effectiveness decreases have occurred. The magnitude of these fines could be determined by the health effects quantification of such decreases in effectiveness. As suggested before, these emergency planning fines could be correlated to fines within the nuclear power plant for operational defects that had a potential comparable health and safety impact.

4. Emergency Action Levels for Security Events

TABLE 4 classifies terrorist events into seven categories and accidents into five categories. It is assumed here that a review of potential reactivity excursion events would show that such sequences are too improbable to be listed in TABLE 4. To complete TABLE 4 a review of classified and unclassified plant security issues needs to be conducted and the more significant ones need to be analyzed with the SOARCA technology. Once analyzed using the SOARCA technology, the onsets and magnitudes of releases would be determined. Using this information and the results of traffic analyses that calculate the time to evacuate the inner two miles from a point of release, the time when alerting is to be initiated can be determined. ***This security related additional information should be added to TABLE 4, scenario T 7, perhaps as a classified document.***

Terrorist events have many potential outcomes ranging from no release if containment integrity is maintained, to very small and very delayed releases if it takes a long time to overpressurize the containment, to larger, earlier releases if the containment is breached and a core melt sequence is initiated soon thereafter. Additionally, there can be attacks on the spent fuel pool, with or without recently discharged reactor fuel in the pool during a refueling outage. Similarly, there is a wide range of accident scenarios, albeit they generally have smaller source terms and longer onset times than those calculated for the most extreme terrorist events. Because there can be many different scenarios, each must be analyzed and a specific emergency response developed for it. By grouping similar scenarios, such as those presented in TABLE 4, the number of different possible emergency responses can be kept to a manageable amount.

It should be noted that for sequences that take a very long time to reach the onset of a release of radioactive material, such as station blackout scenarios, there may be opportunities to terminate the sequence thereby preventing a release. Further, significant changes in wind direction are likely to occur during the time period between sequence initiation and the onset of a release of radioactive material. Additionally, it seems unreasonable to direct the public to either remain sheltered or even indoors during the long time between sequence initiation and the onset of a release of radioactive material. Therefore for slowly developing events of this nature the offsite emergency response would likely have to be broken down into two or more phases. The purpose of the first phase would be just to alert the public of the plant status, generally what mitigative actions are being taken, and when the expected onset of a release might occur if such mitigative actions do not work. The public would be instructed to continue on with its normal activities and monitor the emergency information being announced over the media. The second phase would begin somewhat before the onset of a release. The public would be advised to take specific protective actions and this announcement should be made in sufficient time to evacuate the inner two miles before the expected onset time, if evacuation is called for. Thus for slowly evolving events there are more than one emergency action levels. As indicated in TABLE 4, the emergency protective actions of several other classes of postulated terrorist events would be best implemented by using two or more emergency action levels which are keyed to evolving situations. Conversely, those terrorist events that are characterized by an early loss of containment integrity would likely be best implemented by a single emergency action level.

The key to sorting out the timing of the emergency action levels and their corresponding protective action recommendations rests with identifying the different major accident and security threats, then analyzing their potential core melt progressions and onsets of releases to the environment.

5. Emergency Classification Timeliness

This issue is adequately addressed by comments on issue 4 and by TABLE 4.

6. Emergency Operations Facility-Performance Based Approach

It would be best to locate a consolidated EOF beyond 4 miles of a potential point of release n a well shielded building.

7. Emergency Response Organization Augmentation and Alternate Facilities

One observation that applies to this issue is the use of local emergency personnel in the TSC and OSC. Since almost all health risks are within a short distance from the site and since recommended evacuation would also be limited to a short distance from the site, ***people familiar with local conditions should participate in the decision making at these centers*** including decision making for the protective actions that should be undertaken in the ad hoc area.

There can be additional duties for local governments in assisting special groups in the EPZ, such as transportation-dependent groups, who live close to the site and in assisting those who have walked out of the inner two miles along pedestrian evacuation paths to get to a predesignated shelter. Temporary shelters, such as in well shielded buildings, need to be opened to transportation-dependent groups and the people who have evacuated on foot. Both the transportation dependent population and those people who evacuated on foot to a predesignated shelter will need bus service to take them to a reception center and this might involve local government personnel or other supporting emergency responders.

8. Evacuation Time Estimate Updating

The whole subject of Evacuation Time Estimates (ETE) needs to be overhauled. Evacuation time estimates today are calculations of the time it takes to evacuate the last person out of a ten mile EPZ. The present $ETE_{10\ miles}$ analyses send the wrong message to the public; these analyses imply that the preferred emergency response is a total evacuation of the EPZ. Yet, if a power plant were under armed attack, one does not want to have unintentionally communicated that because of the $ETE_{10\ miles}$ analyses, the preferred response for everyone is to evacuate. (See TABLE 4, case T2). In cases where the time to reach the onset of a release is very long and the source terms would be quite small, an all evacuation response also would be inappropriate. Even when evacuation is called for, evacuation of the whole EPZ is a very poor response that can lead to greater radiation exposure of some people in the EPZ than a response that is a mix of evacuation. Even in those situations where evacuation is called for, none of them call for a complete evacuation of the EPZ.

For cases T3 and T6, instead of analyzing the time it takes to evacuate the whole EPZ, the time it takes the two mile population to evacuate is of far greater importance. Since the preferred emergency response for postulated terrorist events T3 and T6 is prompt evacuation near the site with sheltering beyond this inner area, the majority of downwind people in an emergency should be taking shelter. This issue needs to coordinated with issue 5 on Emergency Classification Timeliness.

Further, $ETEs_{10\ miles}$ analyses themselves do not directly measure risks, nor do increases in the calculated $ETEs_{10\ miles}$ measure risk increases. For example, The Grand Gulf, Harris, and Indian Point have EPZ populations of 16,000, 86,000 and 392,000 people, respectively. Their corresponding $ETEs_{10\ miles}$ are 2:20, 2:35 and 5:20 hours. All of these $ETEs_{10\ miles}$ are acceptable. Unanswered is how does an updated $ETE_{10\ miles}$ scheme in the Proposed Rule provide more protection for the public? What corrective actions need to be taken if calculations show that an $ETE_{10\ miles}$ is longer than previous calculations?

Changes in the population surrounding a nuclear power plant may or may not be important to determining the Evacuation Time Estimate. A change in population level in an area where sheltering is the preferred response won't affect the ETEs unless some people, who should be sheltering or just staying indoors, inappropriately evacuate. An increase in the population level accompanied by an improved road system to support this larger population would not affect the ETEs if these are offsetting effects.

If there are to be Evacuation Time Estimates, then they should concentrate on the time to evacuate the inner two miles, $ETE_{2\ miles}$, or, at most, the time to evacuate the inner two miles and the wedge area. Even if there were an increase in population in the EPZ and some people inappropriately evacuated in an emergency, this might not have any risk significance if it did not affect those evacuating the inner two miles or so. If there is unnecessary evacuation either before the onset of a release of radioactive material or after the release has ended, this should not affect overall health consequences. Increases in population level for slowly evolving sequences like station blackout have no risk significance. Conversely, a site that has temporarily closed a major evacuation route could significantly affect the $ETE_{2\ miles}$.

It is possible to extract from the RBR report some quantified information about the importance of increased population on the time to evacuate the inner two miles and even the health effects impact of longer $ETE_{2\ miles}$ due to higher population levels. Increases in population and its possible impact on health consequences is quite similar to the effects of shadow evacuation which is discussed in the RBR report. TABLE 2 provides an example of the quantification of different sized evacuations on early health effects at the Indian Point site for an extreme terrorist attack (Case T3 in TABLE 4). In TABLE 2, Case B1_ modeled 100% of the EPZ evacuating, i.e., 366,866 people. In Case C1 in TABLE 2, everyone within 4 miles and 35% of the population between 4 and 10 miles were assumed to evacuate. This means that in Case C1 the size of the evacuation was 178,641 people. Comparing these two cases there was about a 100% increase in the evacuating population in Case B1_ relative to Case C1. The calculated impact of this 100% increase in the evacuating population was an increase from two to four people in the calculated number of early fatalities and an increase from 33 to 80 people in the number of early injuries, at the 95% weather condition. At mean weather conditions these incremental increases would be smaller. At other sites with smaller populations a doubling of the evacuating population would have even smaller calculated health effects. A change in the evacuating population of, say, 10 to 15 percent, is expected to have a proportionately smaller effect than doubling the size of the evacuating population. Based on the above, increases in population would not appreciably increase the early health effects even in an extreme terrorist scenario.

As shown above, changes in population level can be quantified in terms of health effects. If it were decided that some change in the population level was large enough to cause an undesirable increase in the number of health effects, other emergency planning changes might be considered to offset this, using the same quantitative technology. For example, steps might be considered which could lead to a somewhat quicker way to alert the public and to start their evacuation sooner. A trade off between warning time and population increase could be determined that would result in a consequence neutral result.

Further, at any given site, sensitivity studies can be performed on the importance of population level increases well in advance of such increases. Changes in road configurations, such as widening or blockage due to repairs could also be evaluated in advance. With this new quantification capability one need not set a specific timetable to update ETE analyses (The inner two mile area $ETE_{2\ miles}$, not the $ETEs_{10\ miles}$ which should no longer need be calculated), but rather it would be better to monitor population changes over time to see if higher population levels indicate that some precalculated compensatory action needs to be taken.

In summary, it is recommended that the present periodic ETE analysis of all nuclear sites where the evacuation of the whole EPZ is analyzed, be replaced by sensitivity studies on health effects and compensatory actions, if desired. It is further suggested that these additional analyses be restricted to a few high population sites.

9. Security Event- Based Drills and Exercises

TABLE 4 should be used as a guide to classifying different security events and how to respond to them. Drills and exercises could then be keyed to these different classes of security events. As mentioned before, deficiencies in executing these drills and exercises can be quantified using modern analytical methods and corrective actions/fines should be commensurate with these quantifications. Different core damage scenarios and different emergency responses produce different impacts on calculated health effects, as shown in TABLES 2 and 3. These different impacts can be ranked according to their size. Those emergency responses that have the largest calculated impacts on calculated health effects should be considered as the priority types of responses to practice in drills and exercises.

5.0 Figures

Figure 1

Figures

FIGURE 1

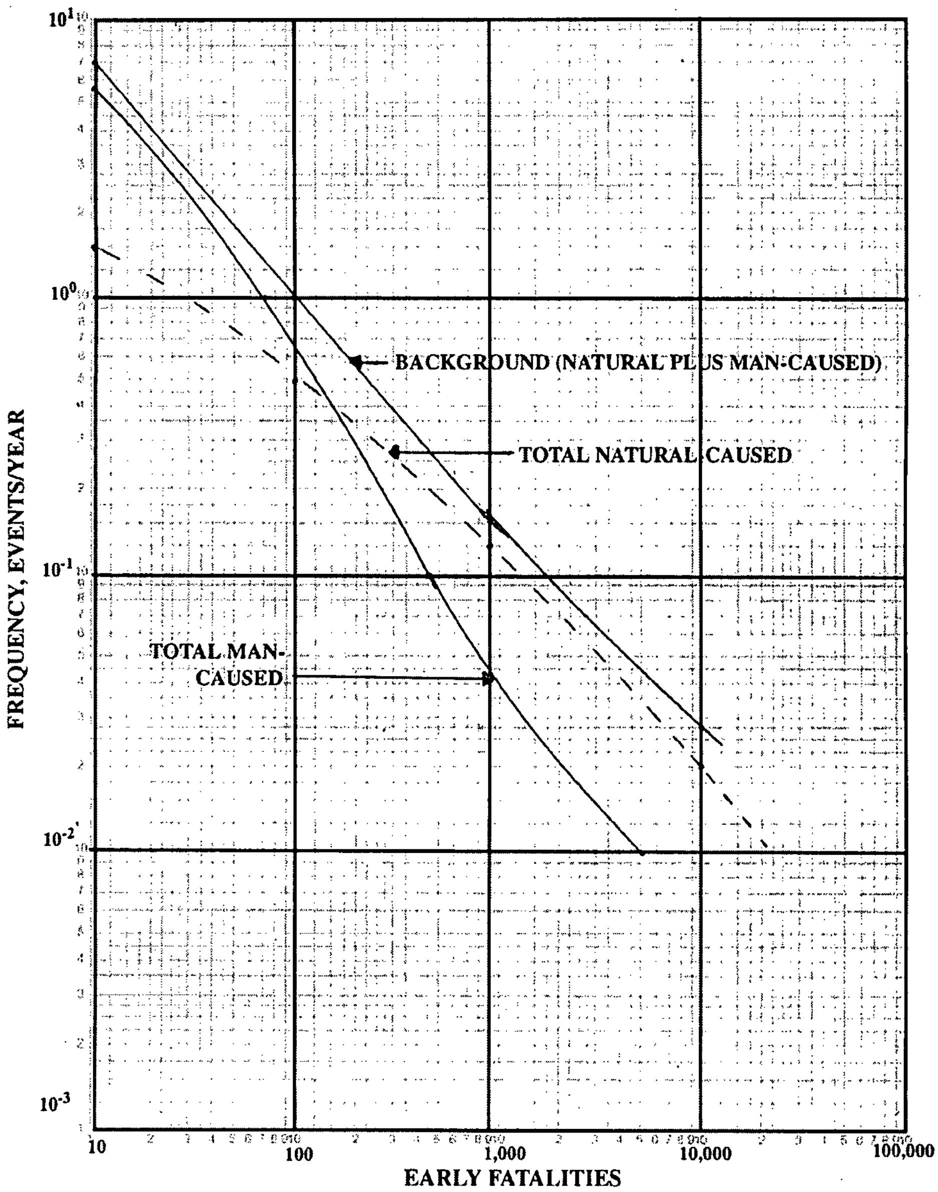

Figure 2

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FIGURE 2

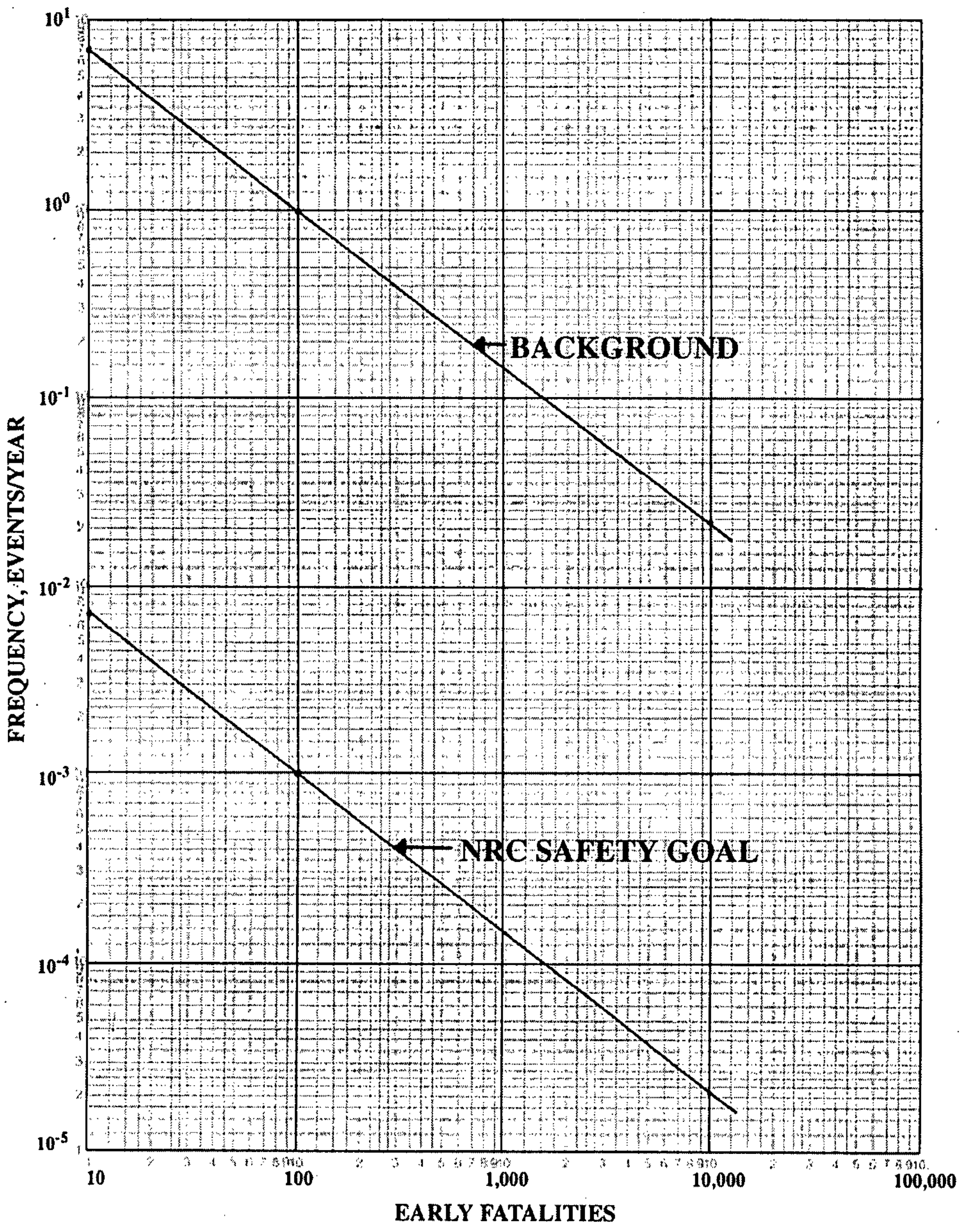

Figure 3

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FIGURE 3

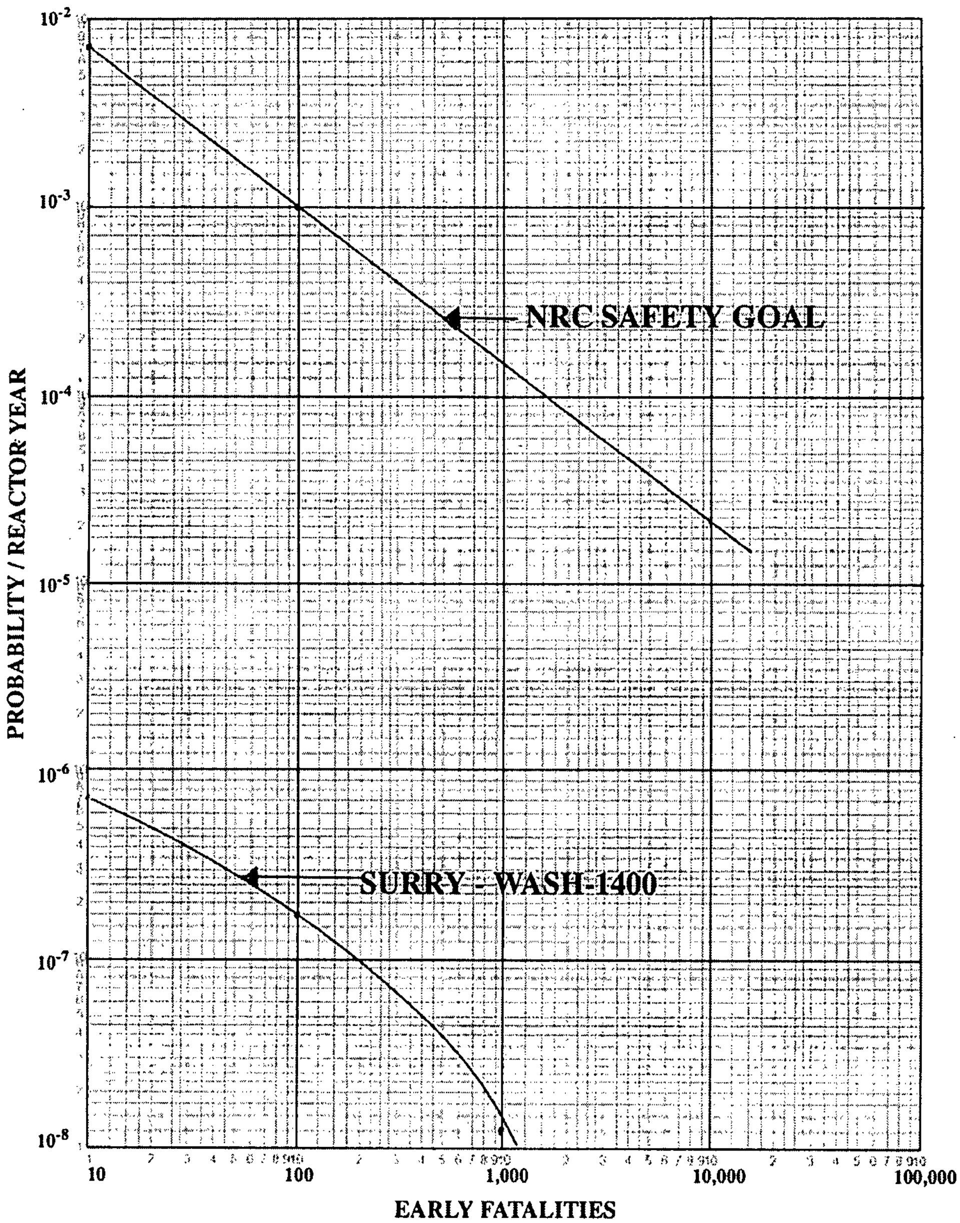
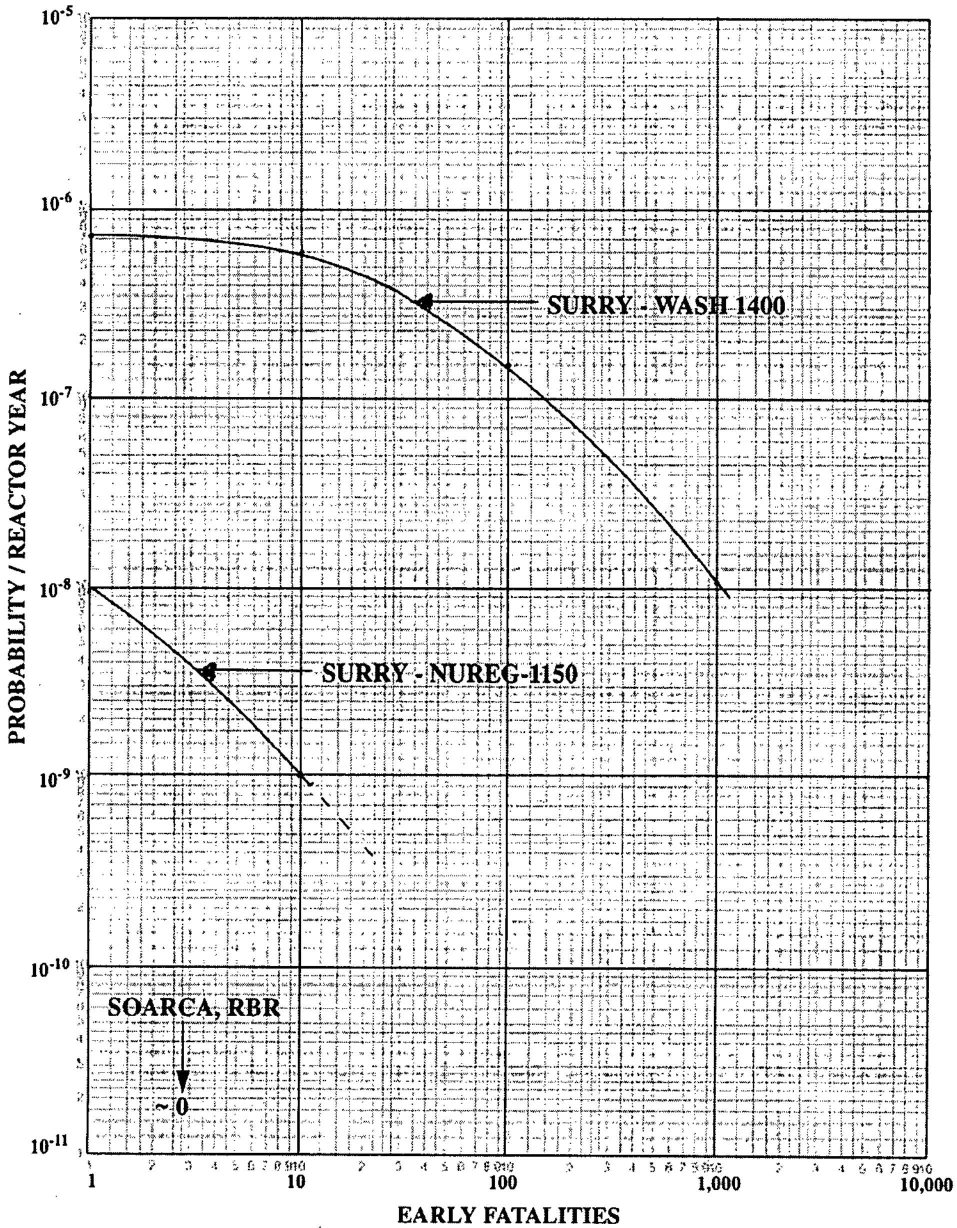


Figure 4

Figures

FIGURE 4



APPENDIX A: Chairman Jaczko's April, 2007 Presentation

The Next Evolution in Radiological Emergency Preparedness: Further Strengthening the Federal Partnership with State and Local Emergency Managers

Prepared Remarks for

The Honorable Gregory B. Jaczko
Commissioner
U.S. Nuclear Regulatory Commission

at the

17th Annual National Radiological Emergency Preparedness Conference
Newport Beach, CA
April 30, 2007

As you heard in my introduction, I have done work in physics which involved analyzing very small systems. The emergency preparedness work you do is about large and complex systems involving many different agencies and levels of government. All disasters are local and therefore you have the primary responsibility for deciding how to plan for and address them. The federal government should help you prepare and respond when the event is of such magnitude that state and local capabilities are overwhelmed. I am glad to be here today and I intend to keep my remarks relatively short because I would like to leave time for a more informal question and answer session.

I have made it a focus on the Commission to work to improve public confidence in the agency. I believe that if we act based on sound technical, scientific, and policy considerations, but do not have public confidence, even the correct decisions can be difficult to implement. The reason I have focused so much on emergency preparedness is because I believe it is one of the areas where that can happen. You and those who have come before you have worked hard to get the resources and technical guidance you need from licensees and the federal government and you have used that to create a very good system of radiological emergency preparedness that has served as the basis for national all-hazards preparedness efforts.

That does not mean that the federal government is doing everything it can to help and it does not mean we all can not evolve and continue to improve. I use as my springboard for today's talk one small section in the Department of Homeland Security's (DHS) Federal Emergency Management Agency (FEMA) regulations, 44 CFR Part 351.21, which describes the Nuclear Regulatory Commission's (NRC) role of evaluating the emergency plans. Section (g) reads as follows:

"Participate with FEMA in assisting State and Local governments in developing their radiological emergency plans, evaluating exercises to test plans, and evaluating the plans and preparedness."

The NRC clearly has the primary responsibility to ensure a licensee's onsite plans provide reasonable assurance that appropriate protective measures can be taken and for reviewing FEMA's offsite findings to make an overall determination of adequate protection for your communities. The regulation I just quoted makes it clear that the NRC has an obligation to stand with you to help you develop the plans that you submit to FEMA.

When I spoke to you last year, I indicated I had visited many of the nuclear power plants the Commission licenses and regulates and met with state and local officials, and public interest groups. Since last year, I have participated in licensee and regional emergency preparedness forums. I have also met with DHS officials and spent a fair amount of time with the NRC's excellent radiological emergency preparedness (REP) staff.

I have concluded that while state and local emergency managers know what they need to have in place to protect their people, we have not done a thorough enough job at the federal level of adapting to technology and changes in emergency management to explain exactly what it means for a radiological emergency preparedness plan to 'work.' Without that, the NRC can not hold its licensees accountable to the extent necessary, and it can not communicate with the public as effectively as it should.

At a Commission meeting last spring I asked a panel of industry, state and local government, and public interest group representatives their understanding of what a 'working emergency preparedness plan' is. They all said that a working plan is one that "protects public health and safety." And of course that is the mission and our ultimate goal. But I believe emergency preparedness is mature enough that the federal government can now do a better job of adding specificity into our regulations to define preparedness. Certainly, the NRC has the 16 planning standards detailed in section 50.47 of our regulations and there is further guidance in Appendix E. And as 44 CFR 350.5(a) states, these regulations "apply insofar as FEMA is concerned to State and Local governments." While those regulations and the guidance contained in NUREG-0654/ FEMA-REP-1 from 1980 are helpful, there is something missing.

Thankfully, the public and the REP community has answered the call once again and helped the NRC staff figure out what those missing elements are. The results are in from a years-long comprehensive review of emergency preparedness regulations performed by the staff that has involved everything from evacuation studies to extensive and unprecedented public participation. The NRC staff proposed, and the Commission approved, beginning to implement enhancements to emergency preparedness regulations and guidance in three main areas: incremental improvements to the existing structure, the inclusion of security-based drills and exercises, and the longer-term exploration of a new radiological emergency preparedness paradigm.

Before I get into a brief discussion of these proposals, let me be clear that it is very early in this process. The agency will be working closely with FEMA and will be proposing the changes in a public rulemakings that provide the opportunity over the next 1-2 years for your input, suggestions, and concerns to be fully included. I trust that our agency will not only continue to listen to your comments but seek to truly resolve them before any of these changes are implemented in 2010. Tomorrow, NRC staff will be providing you with a detailed look at what will be in the proposed rule out for comment later this year but I wanted to briefly mention a few things here. The first category of enhancements involves additional requirements for our licensees to provide government officials with better information more quickly. Based on advances in technology and emergency management over the last quarter century, they deal with such issues as requiring licensees to have a backup capability to notify you and your public of an incident at a plant and performing periodic review and updating of evacuation time estimates to better assist you in making protective action recommendations.

The second category involves the inclusion of security-based drills and exercises, including a security-based scenario for one of the biennial exercises conducted during a 6-year cycle. These exercises may include a spectrum of simulated releases to better familiarize responders with different timing, duration, and severity of events. These exercises will pose some challenges for offsite response organizations, and the NRC and FEMA will need to work very closely with you to ensure they are valuable learning experiences for all of us.

Finally, I am encouraged about the idea the Commission approved exploring over the next few years which involves a different way to look at the NRC's role in emergency preparedness. We all face a number of demands on us, not enough resources to do them, and pulls in many different directions. I know there are several federal government agencies that state and local emergency managers must work with, and reorganizations have been the rule over the last several years. And I know that faced with those pressures and the important mission you do, the idea of a change to the NRC and FEMA regulatory structure for REP can be daunting. But I am here today to ask you to view this proposal with the sentiment captured in your mission statement "in the spirit of continuous self-improvement to.....create innovative planning, exercising, and training methodologies."

I am talking about a different approach that relies more on determining the ultimate goal of radiological emergency preparedness, clearly defining it, and working toward that goal together. It is just a seed of an idea right now, and to grow roots it will take your buy-in, but it is one that has intrigued a diverse group of stakeholders.

These stakeholders understand that in emergency preparedness, the NRC has requirements for developing and maintaining plans, but not for what they must be able to accomplish. In reality, the agency simply has procedural regulations. There should be better clarity for all of the different organizations involved to be able to do their jobs. There should be a focus more on abilities, and results rather than means.

As I see it, you are the emergency preparedness experts and you play the critical role of protecting your citizens. There will never be an NRC employee in your community, for instance, directing traffic in the event of an evacuation, but the federal government does have a responsibility to provide you with easier access to the nuclear expertise resident in the NRC to help you do your jobs in the event of a radiological emergency. As the staff holds public meetings and seeks comments on the proposed rulemaking, they will discuss ways to develop a set of attainable radiological emergency preparedness goals and then design steps to measure how well they can be met.

I believe the best way to do this is to embrace the development of a performance-based definition of reasonable assurance that can be implemented in a graded approach. The agency has defined performance-based requirements as those that have a measurable or calculable outcome. In general, a performance-based regulatory approach focuses on results as the primary basis for decision-making. This approach would result in the federal government being less intrusive, allowing you more flexibility to do your jobs.

So let us have a discussion about what the standard should be, let us quantify the protection that emergency preparedness plans and procedures should result in, and let us codify them in regulations that are transparent, objective, and measurable. I do not know what these new performance-based regulations would look like. They may focus on an evacuation time standard, an amount of dose that should be prevented, or a maximum dose that can be received. Because they would be performance-based, licensees and communities would have more flexibility to address their own challenges and develop their own unique solutions to reasonable assurance.

I think this effort should also be implemented in a graded approach. It should ensure the same amount of protection is afforded to citizens around all nuclear power plants and to do that resources need to apportioned and efforts based upon the unique challenges of each EPZ. Having the flexibility to tailor your efforts in such a fashion would be an improvement over the current system which does not adequately recognize that each plant and each community are different. Because the NRC and FEMA regulations are mostly one-size-fits all, they do not take into account one of the fundamental principles of emergency management that all disasters are local: that each community is unique and local emergency managers must have the flexibility to adopt individual solutions.

Wouldn't it be better if you had the flexibility to look at all the hazards your communities face and put the risk from a rural nuclear power plant with a small neighboring population in its proper context? Making emergency preparedness regulations more performance-based and flexible should be pretty straightforward. Having this dialogue and moving our regulations in this direction will also make it more likely that officials could successfully make dramatic changes to protective action recommendations, if that is necessary in the future.

I am referring to the Sandia evacuation and protective action recommendation studies that the NRC has funded over the past few years. The preliminary results of these studies show that in certain emergencies resulting in releases of radiological materials - such as short duration or 'puff' releases or in communities with longer evacuation time estimates - it may be better for people to shelter in place rather than attempt to evacuate.

There is a widespread perception, however, that radiological emergency preparedness is equivalent to evacuation. Because there is such a belief among many members of the public that evacuation is the best option for a radiological emergency, any discussion about sheltering is seen as an admission that emergency plans will not 'work' and rather than focusing on the best way to achieve our common goal of protecting the public, the dialogue ends abruptly and results in a loss of public confidence. By making clear the ultimate performance measures, emergency officials are more likely to be able to gain the support of the very people who must listen, believe, and follow instructions to effectively shelter in place, if in fact that is the safest course of action for a given scenario.

The significant changes I have outlined will not be easy to accomplish because emergency preparedness is such a complex and emotional issue. It will require that the NRC continue work closely with its FEMA partner, with licensees, and with state and local emergency management officials, to continue to look for ways to make radiological emergency preparedness even more effective. We will address this issue honestly, directly, and with the full participation of stakeholders to strengthen our agency's credibility with the public and ultimately make the job each of us does a little bit easier to accomplish.

Together we can make even more progress in the years ahead. Again, I appreciate this opportunity to speak to you this afternoon. I would also welcome any questions and feedback you may have.

APPENDIX B: RBR Source Terms

			STATION BLACKOUT		
Segment	**Start time, hrs**	**End time, hrs**	**Core fraction, iodine**	**Core fraction, cesium**	**Core fraction, tellurium**
One	4.4	5.5	1.61E-1	1.06E-1	7.00E-2
Two	5.5	8.0	9.60E-2	6.51E-2	1.61E-1
Three	8.0	18.0	1.70E-2	8.82E-3	1.40E-2
Total release	N/A	N/A	0.274	0.180	0.182
			LOSS OF COOLANT		
Segment	**Start time, hrs**	**End time, hrs**	**Core fraction, iodine**	**Core fraction, cesium**	**Core fraction, tellurium**
One	2.0	3.0	2.90E-2	2.90E-2	4.50E-2
Two	3.0	5.0	3.40E-2	3.40E-2	5.80E-2
Three	5.0	15.0	4.80E-2	3.80E-2	1.80E-2
Total release	N/A	N/A	0.111	0.101	0.121

6.0 References

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