1.0 TECHNICAL COMMENTS

1.1 Emergency Planning Zone Concepts and Boundaries/ Public Acceptance

As NRC Commissioner Jaczko has pointed out, it is important for the public to have confidence in the emergency plans for nuclear power plants. How are your results to be offered to a non-technical audience? **It is suggested that the whole subject of how to gain greater public acceptance of the NRC and Sandia emergency planning effort be investigated now and incorporated in the final NRC/Sandia reports.**

Fundamental to gaining public acceptance are the bases by which the NRC would now establish emergency planning zone outer and inner geometric boundaries. Today few members of the public or their elected officials are aware of the very short range of early health effects from potential releases of radioactive material into the environment. As a result of this basic lack of understanding, people do not realize that most health effects are highly localized and that much of the emergency response is correspondingly highly localized. Instead, the public sometimes thinks it is in mortal danger out to very large distances from a nuclear power plant. There often is confusion, sometimes intentionally promoted, between the short range of early health effects and the potentially significant distances where very low levels of radiation might appear following a release of radioactive material. **This needs to be clarified in the NUREG.**

It appears that the public is also unaware that the very nature of potential health effects from exposure to radiation changes rapidly with distance. The shortest ranged health effect is the possibility of becoming an early (prompt) fatality. A typical range, out to the 95th percentile weather condition, is one mile or less. Use of the expression "95th percentile" means that 95 percent of the weather conditions would result in early fatality consequences less than this figure. Expressing consequences in this format is conservative and can avoid long discussions of peak consequences and peak distances which inevitably lead to other discussions of sequence frequencies and acceptable risk; subjects which the public may find difficult to grasp. Early injuries have a typical range of about two miles from the point of release, at the 95th percentile. Unless there is some kind of threshold, low level radiation could lead to latent (long term) health effects at indefinite distances. **It is therefore necessary to explain to the public why evacuation out to great distances is not necessary, even though some level of radiation might be present there following a release of radioactive material.**

It is therefore important to establish fundamental emergency planning geometric boundaries based on the ranges of potential early and latent health effects from postulated releases of radioactive material into the environment. The most fundamental boundary is the outer radius of the Emergency Planning Zone (EPZ). It is important to convey to the public and their elected officials that detailed emergency planning is applied to the people within the EPZ, but that people beyond the EPZ are not forgotten, as some members of the public now fear. The outer radius of the EPZ should be chosen to be well beyond the 95th percentile early health effects ranges, i.e., beyond two miles. The rationale for setting the EPZ outer boundary would then depend on the latent fatality consequence distribution. **It is suggested that beyond the EPZ radius *ad hoc* protective actions would be appropriate and would result in limiting health risks at or below the NRC's reactor latent health safety goal.** *Ad hoc* actions in this outer region would be appropriate because dose rates and integrated doses in this region would be quite low; because the time to take protective actions would be long; because simple, yet quite effective, protective actions could be taken quickly by the public without significant assistance from emergency responders; because emergency responders would already be active inside the EPZ and could offer assistance outside of the EPZ if needed, and because all the other aspects of public protection, such as the distribution of emergency information and guidance, would be operational and available to them. Therefore the outer radius of the EPZ divides public protection into two main areas: closer areas that warrant detailed planning and further areas where *ad hoc* responses would be appropriate. Stated differently, the public is always protected. Within the EPZ protective actions are carefully planned and outside of the EPZ protective actions would be based on timely *ad hoc* actions.

It is unlikely that, even with highly implausible accident sequences, evacuation beyond the EPZ would be necessary. Unless people are in a hot spot, the appropriate *ad hoc* response beyond the EPZ should, at most, be limited to taking shelter, if downwind. Others, further away but still downwind, might be advised to just go indoors. People who are not downwind could conduct themselves in a normal activities mode, but with the suggestion that they stayed tuned to emergency broadcasts until the emergency is declared to be over. NUREG/CR- 6953 is helpful here in that it identifies sheltering as an *ad hoc* protective action that has been successful in actual emergencies. The use of sheltering will be discussed further in this letter.

Part of the task to establishing the outer radius of the EPZ using modern technology is the recognition that the historical approach that led to the present ten mile distance is no longer technically supportable. Earlier emergency planning boundary setting methods tied the EPZ radius to the conditional probability of causing an early fatality versus distance. This specific analysis is found in NUREG 0396 which dates to December, 1978. Since that time our knowledge of accident sequences, source terms, and health effects has greatly advanced. If NUREG 0396's approach were used with today's much smaller source terms, this would yield a much smaller EPZ with a radius of about two miles or less. However, this much smaller radius would ignore potential latent health effects that might arise out of exposure to radiation during plume passage. An important purpose of emergency planning is to limit such possible long term health effects. Therefore it appears to be necessary and appropriate to establish the size of the EPZ based on latent health effect considerations. Specifically, it is technically possible to establish a modern EPZ radius based on the Commission's latent fatality safety goal. **Using the results that are being generated by the SOARCA studies, a modern approach to establishing the outer radius of the EPZ might be to require that a person who operated in a normal activities mode for 24 hours at the EPZ radius would not have latent fatality risks that exceeded the limits set by the NRC's latent fatality safety goal, assuming that a release of radioactive material to the environment had occurred.**

There are three <u>inner</u> radii within the EPZ that are very important. I believe that **the Commission would greatly benefit by making its own analysis of these three radii because they profoundly affect the creation of highly effective emergency plans and the public's perceptions of nuclear power plant risks.** As mentioned above, the two innermost radii, at the 95th weather percentile, the early fatality and early injury distances, one and two miles, respectively. The third inner radius is the distance at which sheltering, not evacuation, is the preferred emergency protective action. Site specific analyses indicate that sheltering beyond four miles (possibly less), even for considerable lengths of time, is sufficient to prevent long term health effects for sheltered people from exposure to radiation during the plume passage period.

One consideration in the sheltering analysis that is worthy of a closer look is the assumption of air infiltration. The air infiltration effect is itself based on whether one assumes that steps are taken to reduce air in leakage, such as turning off furnaces. It appears that the NUREG's generic analysis used one model for air infiltration and the site specific analysis used a different model. The choice of which air infiltration model is used may affect the determination of the range of the third inner radius, i.e., the point at which sheltering is preferred to evacuation.

1.2 Sheltering

Optimum emergency plans utilize a mixture of sheltering and evacuation. Much of the discussion of sheltering in NUREG/CR-6953 is devoted to sheltering responses if there are impediments to evacuation or during very rare circumstances where there could be a rapid release of radioactive material. Unless there is some kind of destructive power excursion, it is difficult to identify a scenario where the release would be so rapid that sheltering near the site would be preferred to nearby evacuation.

The NUREG's description of a sheltering response is one where evacuation would follow an initial period of sheltering. **This concept needs to be examined further to determine the cross-over point, i.e., at what length of time would the shelter first, evacuate later strategy be less protective than starting to evacuate initially? The staff may also wish to investigate the use of wet handkerchiefs or simple face masks to reduce inhalation doses while sheltered.** The NCRP has indicated that such devices can be quite useful under certain release conditions. Reduction of the inhalation dose would extend the time when sheltering would be more protective than evacuation.

In all release sequences the use of sheltering, not evacuation, for downwind areas beyond four miles is strongly recommended. Of particular concern are the additional risks associated with overevacuation. In general, the greater the number of people evacuating, the slower the evacuation. This may be of limited concern at low population sites, but overevacuation at high population sites can cause a net increase in health consequences. Further, overevacuation could result in overwhelming the resources at reception centers, particularly those centers further from the plant site. By using sheltering beyond four miles as the preferred emergency response, the possibility of overevacuation should be reduced considerably.

There is a concern that some people might be unwilling or unable to return to their homes having once been instructed to evacuate. The ongoing hardships of long term displaced evacuees from Hurricane Katrina is a warning that **the evacuation of people needs to consider both radiation issues and many other longer term non radiological issues.** This broader discussion of issues related to evacuation should encourage the development of emergency plans that balance evacuation and sheltering more optimally. **Discussions in NUREG/CR-6953 of the time available to evacuate beyond the EPZ, <u>even with an intact</u> <u>containment</u>, might be revised to reflect that sheltering at <u>all</u> downwind distances beyond four miles is preferred to evacuation for all situations;** certainly those where containment integrity is maintained but also those where containment integrity might be lost. Statements about evacuating beyond the EPZ, even with an intact containment, can lead to overevacuation which, in turn, can increase consequences.

NUREG/CR-6953 might be expanded to include pedestrian evacuation as a supplement to evacuation in a vehicle. Such evacuation has numerous benefits. Predesignated pedestrian evacuation paths could be used by those that prefer this protective action, thereby reducing the possible number of vehicles on the road. Pedestrian evacuation would likely start immediately, once the public became aware of an emergency, i.e., a very short mobilization time. Studies show that there are significant benefits to starting to evacuate as soon as practical. If someone starts to evacuate on foot and leaves before the onset of a release of radioactive material, normal walking speeds is sufficient to prevent doses that could lead to an early fatality.

1.3 Improved Keyhole Designs

Modern technology permits a further optimization of the shape of the keyhole response within the EPZ. At present, keyhole responses cover a circular inner area with a two mile radius, then a downwind "wedge" area three sectors wide out to distance of five miles. The centerline of this wedge area is oriented to the prevailing wind direction and changes locations as the wind shifts.

Wind persistence measurements indicate that for some sites, perhaps many, the wind changes direction frequently. Such wind direction changes were observed in 1979 during the Three Mile Island accident. A study of the 1995 through 1997 wind persistence data at Indian Point show frequent wind changes to be the case. Further, source term analyses show that there can be a considerable time between the initiation of a release sequence (usually identified as the time of reactor scram) and the onset of the release to the environment. Prior to the release of radioactive material to the environment there is some probability that the wind will shift so that the orientation of the keyhole at the time of scram and the wind direction at the onset of the release could be different. Under such circumstances, the evacuation may not be optimal as emergency responders attempt to cope with a changed wind direction. On the other hand, emergency responders would not want to wait to initiate an evacuation until the actual onset of a release, just to have the keyhole more precisely oriented.

An improved keyhole shape could be one where the outer radius is set at about four miles, not five, but that the wedge area is expanded beyond three sectors. A four mile outer radius of the wedge area instead of five is appropriate because, as discussed before, sheltering would be the preferred response beyond four miles. At this distance the early health risks are effectively zero and, with sheltering, the latent health risks are also near zero, even if there are long sheltering durations. A four mile outer radius of the keyhole would bring consistency between the keyhole shape and the important radii discussed previously.

A wider wedge area would mean that there is a greater probability that the wind direction at the time of the onset of the release would fall within the keyhole area. Using Indian Point wind persistence data, the probability of the wind shifting out of the keyhole as a function of time were examined. For example, if there were two hours between the initiation of an accident sequence and the release of radioactive material there would be about a 72% probability of a one sector shift in wind direction during this time period. A wind shift of this magnitude would still be within the present three sector wide keyhole. A three sector shift at two hours is less likely, about 33%, but would result in a release outside of the original orientation of the keyhole. A five sector and a seven sector wind shift within two hours have probabilities of occurring of about 20% and 13%, respectively, at Indian Point.

Clearly a wider keyhole reduces the probability that a release would be outside of the original keyhole direction, but its larger area could potentially increase burdens on the public and the emergency responders. However, with compensatory actions, overall burdens with an optimized keyhole might remain about the same. The reduced area of the wedge caused by moving the outer radius from five to four miles could offset the increased wedge area incurred by expanding the present wedge angle beyond three sectors. For example, a wedge 5.25 sectors wide (118 degrees) and with a four mile outer radius has the same area as the present three sector wedge that extends to five miles. Wedge areas wider than 5.25 sectors would increase the probability that the wind direction at the onset of a release would be within the keyhole area, but at some penalty in increased burden. If it is determined that the radius at which sheltering is preferred to evacuation occurs at a distance less than four miles, then an even wider wedge area could be utilized, while still maintaining today's overall keyhole area. For example, if the outer radius of the wedge area were 3.5 miles, a wedge angle of 7.6 sectors (172 degrees) would have the same area as the present wedge design but a significantly smaller probability that the wind would shift out of the wedge area in a two hour time period following reactor scram.

It is suggested that the Commission gather data from many sites on wind shifts and merge these data with source term analyses, which describe the timing of the onset of releases, to derive an improved approach to establishing keyhole wedge angles. It is further suggested that detailed analyses be performed to more precisely determine the radius at which sheltering would become the preferred emergency response and that the outer radius of the keyhole be set by this analysis.

1.4 A Generic Emergency Plan

Using the results from Sections 1.1 and 1.2, above, it would be possible to develop a Generic Emergency Plan. Such a plan which would utilize the same EPZ geometry at all sites and the same protective actions area by area within all EPZs. **It is recommended that the NRC support this concept of a generic emergency plan** where there would be an inner circular area, two miles in radius, where the preferred emergency response would be evacuation, as is the case today. This inner two mile area should be sufficient to "capture" a very high percentage of the early fatality and early injury risks. From two to four miles (possibly less) there would be the wedge area of the improved keyhole whose angle would be at least 118 degrees wide. Prompt evacuation of this wedge area would be the preferred emergency response, as it is today. Beyond the wedge area and extending to the outer radius of the EPZ, the preferred response would be sheltering. This sheltering area would have the same angle as that used in the keyhole wedge area. Some highly localized delayed evacuation of "hot spots" might take place in this outer area as determined by actual measurements of radiation levels. The outer boundary of the sheltered area would be determined using the Commission's latent health safety goal. Specifically, the boundary between the EPZ and the outer *ad hoc* region could be such that if a people were at this boundary, their latent health risks would not be greater than one part in a thousand, compared to background latent health risks, assuming a normal activities response for 24 hours after the release of radioactive material. Note that this approach to setting the size of the EPZ is not based on a consequence-only criterion, but is based on a risk criterion (the NRC's latent health safety goal) because it also includes the frequencies of releases from a damaged plant. As a practical matter, people at this EPZ boundary would be advised, on an *ad hoc* basis, to take shelter so that their long term risks would be considerably smaller than one part in a thousand. People further from this boundary would have smaller latent health risks and if *ad hoc* actions, such as sheltering, were taken their latent health risks would be even smaller.

The health risks from releases of radioactive material are site and accident sequence dependent as discussed below. However, our analyses indicate that the approach to establishing the outer boundary of the EPZ based on the NRC's latent health safety goal, the use of optimized keyholes and the recommended protective actions at different locations within the EPZ lead to a generic emergency plan. Although there are different population distributions at different sites, different road systems and different sets of plant accident sequences, these differences do not affect the use of a generic emergency plan. Such differences would result in some variations in consequences, but would not alter the determination of important boundaries or protective actions within these boundaries. It is likely that this generic emergency plan would also be adequate for advanced reactor designs that are not based on LWR technology.

It is also recommended that all sites utilize a limited area precautionary evacuation under conditions where a General Emergency might be declared. NUREG/CR- 6953 supports the notion of selective early evacuations. The area that would be advised to have a precautionary evacuation might be limited to that encompassed by the radius of the 95th percentile early fatality risk, approximately one mile. If it turns out that there is no release of radioactive material, then a precautionary evacuation of this inner one mile would have only inconvenienced a small percentage of the EPZ population. Because core melt frequencies are small, the use of precautionary evacuations should be rare. On the other hand, if there were a release of radioactive material into the environment, a precautionary evacuation of the inner one mile would be very effective in reducing all radiation caused health effects, but especially early fatality health effects. Limited area precautionary evacuations could be especially valuable in dealing with terrorist events, such as hijacked large airplanes. It seems likely that such an event could also have additional warning time before the airplane struck a nuclear site, thereby enhancing the possibility that the inner one mile would be totally evacuated prior to the start of a core melt sequence.

A precautionary evacuation is a two step process. If the alarm for a precautionary evacuation is sounded, the first step would have those within one mile start to evacuate, whereas people beyond the inner one mile would be advised to just stay indoors and listen to emergency instructions over the media. If further plant degradation occurred, then the generic emergency response would be implemented. However, if the emergency at the plant ended without further degradation, then the precautionary evacuation would likewise be terminated.

Even with all sites using the generic emergency plan (and precautionary evacuations) there would be site-to-site differences in risk levels. Low population sites, particularly those with not many people within several miles of the site, inherently have lower risks because there are fewer people at risk and evacuations would be more rapid. For these sites the generic emergency plan would be sufficient and near zero early and latent health effects would be expected. Emergency plans for sites with higher populations might include additional protective actions beyond the generic plan to lower the risks to their surrounding populations. For example, medium and high population sites might seek ways to reduce the time between accident initiation and the announcement of a General Emergency. The highest population sites might go still further by employing reverse laning of specific segments of evacuation routes, so that evacuation speeds would be somewhat greater. Higher population sites might also locate a portion of their reception centers to be in well shielded facilities beyond four miles, but still within the EPZ. Use of these closer-in reception centers should reduce the time it takes buses to make emergency round trips from these closer-in reception centers to predesignated well shielded buildings within the inner two miles to pick up people who do not have their own transportation means. Such closer-in reception centers should be able to support adequate emergency transportation using fewer buses and fewer bus drivers. These closer-in reception centers would also offer family members who work outside of the EPZ practical alternative locations where they might rejoin their families, rather than attempting to drive to their homes. This redirection of some traffic to these closer-in locations should speed up the emergency response of people within the inner four miles, while providing families with more options on how they would become reunited.

Plant personnel on duty at the nuclear plants in higher population sites might be assigned to predesignated well shielded buildings within the inner two miles. This would assure that these facilities would be open during an emergency and that the people sheltered within them are well informed and protected as they wait for their evacuation buses arrive. Beyond two miles, buses would be assigned to rapidly evacuate people that need transportation assistance from bus stops identified as on an evacuation route.

It is suggested that the NUREG should focus on the use of just a limited number of predesignated shelters and on the use of in-close reception centers.

1.5 Quantification

It is now possible to <u>quantify virtually all emergency protective actions</u> in terms of their importance to early and latent health effects for any site and for any release sequence. This can be accomplished with improved versions of the MACCS2 code that are merged with advanced traffic analyses. With this advanced quantification capability different protective actions can be ranked as to their consequence reducing significance. If the probability of a release sequence is known, this consequence ranking of protective actions can also easily be presented as a risk ranking. Risk ranking provides a method to distribute limited resources in an optimal way.

With the advent of the capability to quantify virtually all protective actions in terms of health risks, emergency planning then becomes a risk informed-performance based regulatory process, consistent with the same regulatory processes used within the physical boundaries of the plant. Thus a regulatory continuum would be created that ties together systems, structures, components and operator actions within the plant to offsite protective actions, all expressed with the same metrics as used in the Commission's Safety Goals, early and latent fatality health risks. The enormous benefits of the risk informed-performance based regulatory process that have been witnessed within the plants since 1992 could now be expected off site. For example, the implementation of a risk informed-performance based regulatory process within the plant has led to a greatly improved Commission inspection process where resources are expended according to risk significance.

Similarly, the evaluation of emergency drills could quantify deficiencies, if any, according to their risk significance.

The ability to quantify emergency actions has many applications from evaluating specific strategies, the importance of specific drill deficiencies, to an overall evaluation of risk levels with and without a formal emergency plan. Quantification of risk significance, both inside the plants and off site using the same metrics of early and latent fatality risks, establishes a process through which further optimization could take place. For example, it might be shown that a portable device that supplied of electricity to critical plant safety features and/or water to containment sprays could be more valuable than risk reductions brought about by more extensive off site emergency responses. Such portable devices would have the added advantage of minimizing off site economic risks. Preliminary designs of such portable devices were made in the early 1980s and today are being considered in the B.5.b efforts.

It is recommended that the Commission establish a goal for emergency planning: That it becomes a quantitative risk informed-performance based, regulatory process for non-terrorist events.

1.6 Site Population Differences

NUREG/CR-6953 used the simplification of a constant population density. It is anticipated that ongoing analyses will examine specific plant sites with different population densities. Nuclear sites may be placed into three groups: low, medium, and high population density sites. **It is possible for the NRC staff to make a first approximation <u>now</u> as to what percentage of present plant sites fall into each of these three categories.** A low population site would have approximately zero early and near zero long term health effects from exposure to radiation during plume passage, provided that it used the generic emergency response described above, including a precautionary evacuation strategy. It is anticipated that close to 90% of the present sites would fall into this category. This figure of 90% was derived from a sensitivity study at the Indian Point site where the number of people assumed to be evacuating the EPZ was varied. Early fatality consequences were calculated for several of these evacuation analyses. At an assumed population level of about 195,000, evacuation speeds in the inner two miles would be about six miles per hour (the balance of the EPZ population was assumed to take shelter). Even with a three hour mobilization time, this speed would be sufficient to effectively eliminate early health effects which almost entirely fall within two miles from the point of release. These same studies showed that a larger evacuating population, around 272,000 people, would have an evacuation speed of about 4.4 miles per hour in the inner two miles. Even so, the number of early fatalities, at the 95% exceedence level was calculated to be two. With 100% of the EPZ evacuating Indian Point, about 367,000 people, the inner two mile evacuation speed decreases to 1.4 miles per hour and the calculated 95th percentile number of early fatalities is five. The staff might be able to improve upon the Indian Point based estimate of the number of low population sites by extracting inner two mile evacuation speeds versus EPZ population from previous Evacuation Time Estimate studies at different sites to determine what percentage of the nation's nuclear sites are expected to have speeds in excess of six miles per hour. This percentage would be a good estimate of the number of low population sites. A medium population site might be defined as one that has a 10 mile population between 195,000 and 285,000 people and a high population site would exceed 285,000 people in the surrounding 10 miles. About 6% of the sites would be in the medium category and the remaining 4% in the high population category, using the above population level categories. It is expected that a medium population site would have zero and two people and a mean latent fatality figure between zero and 60 people for an assumed successful terrorist event.

It is expected that the number of early fatality risk at all sites, including the high population sites, would be near zero if the generic emergency plan and precautionary evacuations were implemented. Non-zero latent cancer consequences are expected at medium and high population sites, however these long term consequences would be a very small fraction of naturally occurring background cancer fatalities within the surrounding ten mile population, on the order of one part in 800 or more in the case of Indian Point. This is a consequence-to-consequence comparison. If sequence frequencies are used, a comparison of the nuclear plant latent health effect risk to the risk of cancer fatalities from natural causes would show a much smaller ratio than one in 800. Since sheltering beyond four miles is thought to be sufficient to prevent latent fatalities during plume passage, these calculated latent fatalities are expected to occur among those people whose evacuation started within the inner four miles.

Whereas a low population site is expected to have near zero latent heath effects, the medium and high population sites are expected to have some latent effects. The difference between a medium and a high population site could be that special latent consequence-reducing actions may not be cost-effective at medium population sites but may be worthwhile at the few high population sites. For example, reverse laning might be a valuable strategy at high population sites but of marginal value at medium population sites (and negligible value at low population sites).

1.7 Other Technical Comments

In my opinion there needs to be a more extensive discussion of the relationship between terrorism and emergency planning. Attacks on containment buildings by large airplanes are a popular public concern. Even though the absolute frequency of terrorist events is unknown, many other insights are known. Such aircraft usually carry very large quantities of jet fuel and the post-collision fires that would ensue could result in very buoyant plumes, assuming a radioactive release from the containment did occur. Buoyant plumes have very limited early health effects, independent of emergency responses, as observed at the Chernobyl accident. Aircraft attacks would also be self- announcing, independent of any siren or other alerting system. The fuel-air explosion that would follow a collision of such aircraft with the containment building would be heard and seen for miles, well beyond the early fatality radius. This self-announcing characteristic may result in evacuations that start sooner than those associated with accidents which have built in delays between the initiation of an accident sequence and a public warning. I have attached a critique of Dr. Edwin Lyman's "Chernobyl on the Hudson?". This critique might be useful to you in that the whole issue of plume buoyancy following an aircraft crash into the containment building is discussed as well as some insights on fast breaking accidents. If you do not have a copy of "Chernobyl on the Hudson?" please let me know and I will forward one to you.

Other types of terrorist events not involving aircraft also have aspects that reduce their potential consequences. Because terrorists must overcome containment integrity to be harmful to the public, this could provide longer warning times than certain accident events, such as containment bypass events. This additional warning time, during which evacuation might commence, would reduce the potential health consequences of terrorist events. So airborne and ground level terrorist attacks have particular offsetting characteristics that reduce their feared consequences. If the staff concludes that the emergency response to terrorist events is encompassed within the generic emergency plan, described above, then this should be conveyed to the public and its elected officials.

A very useful exercise would be for the NRC/Sandia to calculate the source terms for two assumed terrorist sequences for a PWR with a large dry containment. Assume that a large hole exists in the containment at T = 0 and that a core melt sequence is started a half hour later. One sequence would be a loss-of-coolant sequence, say a severed six inch pipe, and the other core melt sequence would be for a station blackout. The resultant staff terrorist-based source terms could be directly compared to the ones used in the site specific analysis. **Then, using these NRC/Sandia source terms, the postulated health consequences should be calculated using the integrated traffic/consequence methodology developed for the site specific analysis.** Such calculations would represent the merging of the NRC/Sandia source term work with the traffic analysis/health consequence analysis used in the site specific study and should be supportive of SOARCA goals.

The concept of a lateral evacuation strategy needs further review. If evacuating by vehicle, one is confined to the road system. This may, at times, result in actually driving into the plume, not away from it. However, the time to cross through a plume is very short, a matter of minutes, even at slow speeds, for the narrow plumes associated with peak consequences.Wider plumes take longer to cross but because of their lower dose rates result in lower early health consequences. Lateral evacuations are far less important beyond the first one mile from the point of release, i.e., beyond the range of the early fatality risk. Beyond four miles where sheltering is preferred to evacuation, the subject of lateral evacuation is not relevant for those people in a sheltering mode. Those evacuees that originated within the inner four miles and would still be evacuating beyond this distance would not particularly benefit from a lateral strategy. Once advanced traffic analysis is combined with advanced consequence analysis, the calculation of health effects from exposure to radiation along actual road systems would incorporate lateral and circumferential movements and would obviate the need for developing a separate lateral evacuation strategy. Limited early fatality and early injury consequence calculations were made for Indian Point which compared the calculated radial evacuations to consequences based on traversing the actual road network. The calculated early health differences for these different evacuation models were very large, with the actual road network showing far fewer early health consequences. The actual road system is a grid-like arrangement near the plant site. This causes evacuating traffic close to the site to alternate between radial evacuation and circumferential evacuation. In other words the actual road system has lateral evacuation built right into it and no announcements to the public to evacuate laterally would be necessary or useful. The usual MACCS2 radial evacuation model ends up aligning some portion of the evacuating public with the centerline of the radioactive plume where they would be subjected to very high dose rates. A large fraction of the radial evacuation model early fatality consequences arises out of the situations where the centerline of the plume and evacuees co-exist.

In my view, the subject of Evacuation Time Estimates (ETEs) needs to be reevaluated. Today ETEs are developed assuming a complete evacuation of the EPZ. This sends the wrong message to the public if evacuation is to be limited to four miles, as recommended above. Further, ETEs represent a poor figure of merit. ETEs are the time to evacuate the last person beyond some point, like ten miles. Yet the time distribution of people evacuating can have a greater influence on consequences than the maximum time, which is the ETE. Further, ETEs, the longest time it takes people to evacuate a given area, is the sum of two parameters, the time they take getting ready to evacuate, i.e., the mobilization time, and the time that people are actually in transit. At low population sites the ETE is dominated by the mobilization time since transit times are very short. At high population sites ETEs are dominated by the transit time, especially if there is a "choked flow" situation. Of greater importance is what protective actions people take before they start their evacuation. At low population sites people might be out-of-doors rounding up livestock before they start their own evacuation. At high population sites people might be sheltered for much of the time before they start their evacuation, especially if they are waiting for the return of a family member. Therefore it is possible to have two similar ETEs that result in very different health effects. ETE comparisons have some value at this stage of the overall program but would likely have less value as quantification methods, as described in Section 1.5, come into greater use.

Some discussion of emergency responses during releases from spent fuel pools would be helpful. It may be possible to cover this subject just by reference to earlier NRC reports. Emergency plans developed for releases from the reactor core should be quite sufficient to handle postulated releases from spent fuel pools.

The need for KI pills appears to be essentially zero beyond four miles for those people who take shelter.

1.8 More on public acceptance

It is doubtful that the public is aware that strict early and latent fatality safety goals were established years ago by the Commission that limit nuclear power plant risks to less than one part in a thousand, compared to the background risks that the public itself has found to be acceptable. Further, few members of the public are aware that both the history of plant operation and risk calculations have shown that actual risk levels are far below these strict health safety goals.

Because of the SOARCA program, it is imperative that the NRC explain to the public what it has been learned. One subject worthy of special attention is the important role played by natural forces in limiting releases of radioactive material into the environment. Even if all of the engineered safety systems failed there are still natural forces that serve to protect the public. A list of these natural forces that would be operative in the containment is presented in Chapter 5 of NUREG-1465, "Accident Source Terms for Light-Water Power Plants".

Once outside of the containment other natural forces come into play which also afford public protection. These include meteorological forces which tend, through diffusion, to make radioactive plumes less concentrated as they move away from the point of release. Decreases in the concentration of radioactive material in a plume cause decreases in exposure to radiation. Human biology is such that even small decreases in exposure to radiation drastically reduce the likelihood of an early fatality. This human biological characteristic causes the range of the early fatality risk to be quite short, typically less than a mile, even for severe releases.

These natural forces are apt to be appealing to the public because they do not require any safety equipment or operator action to limit radioactive releases to the environment. No act of terrorism can defeat them.