Instructor Guide: IND Shelter / Evacuation Strategies

TRAINING DOCUMENT

TITLE:	Shelter and Evacuation Strategies (LA)
REQUIREMENT:	Personnel will be informed on the best shelter and evacuation plans following detonation of an IND
TARGET GROUP:	Radiological emergency responders and planners at the local, state and federal levels
TIME ALLOTTED:	30 minutes
INSTRUCTOR (s):	Health Physicist with Emergency Response Background
METHOD OF INSTRUCTION:	Presentation

Prepared by: Brooke Buddemeier, CHP, Lawrence Livermore National Laboratory
Erika Olsen & Shaida Arbabha, DHS Scholars at LLNL
Date: July 2011

Please provide feedback for these draft documents to brooke2@llnl.gov

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

Instructional Goal

This module gives an introduction to the basic principles of fallout, how it changes in time and space, as well as the planning guidance zones and .and definitions

Instructional Objectives

- Provide basic information about how and where to shelter-in-place

- Define the Dangerous Fallout Zone
- Give figures and explanations for why sheltering-in-place works
- Explain the concept of informed evacuation
- Discuss the best public strategy options

At the completion of training, the trainee will be familiar with:

- Different sheltering and evacuation strategies, as well as how many lives these strategies have the potential to save..

Handouts

Student Guide

Trainee Preparation

This presentation is the third in a series, Previously covered material Includes:

- Nuclear Detonation Modeling and Response Planning
  - Congress identified IND response planning as a priority and part of an all-hazards response planning
  - IND updated analysis indicates a significantly improved understanding from cold war planning
  - Federal and National IND specific response guidance
  - State and local planning is critical to reducing initial loss of life.
- IND Prompt Effects
  - Defined prompt effects from a low yield (10 kT) nuclear explosion
  - Define planning guidance (damage) zones
  - Review recent studies and current understanding of nuclear effects
  - Review response strategies
- IND Fallout Effects
  - Define fallout and explain how it is created
  - Explain how fallout spreads
  - Explain the decay rate of fallout
  - Define planning guidance zones

Shelter and Evacuation Strategies (LA)

- Introduce yourself
- Explain your background
- Why you are giving the presentation

Key Fallout Considerations

Click –Fallout decays rapidly (releasing more than half of its energy in the first hour)

The radiation levels are very high initially, but over 50% of the energy comes off in the first hour.

Click –Animation starts/The primary hazard from fallout is being exposed to penetrating radiation from the particles

The hazard is the "waves" of penetrating radiation energy given off by the fallout particles. Getting as much distance and mass between you and the particles is the best protection. By remaining indoors and seeking the best possible shelter in their structure, people can dramatically cut down the radiation dose they are exposed to.

Click –Dangerous levels of fallout are readily visible as they fall

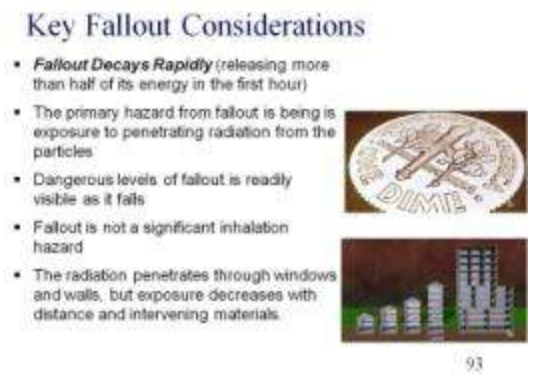
Dangerous levels of fallout are not invisible; there will be visible quantities of material raining down, often the size of salt or sand.

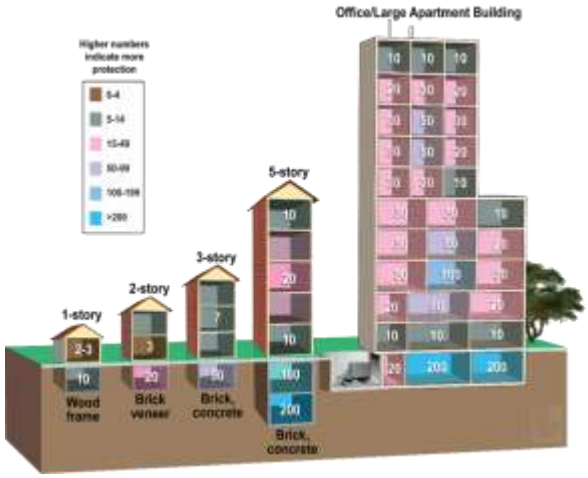
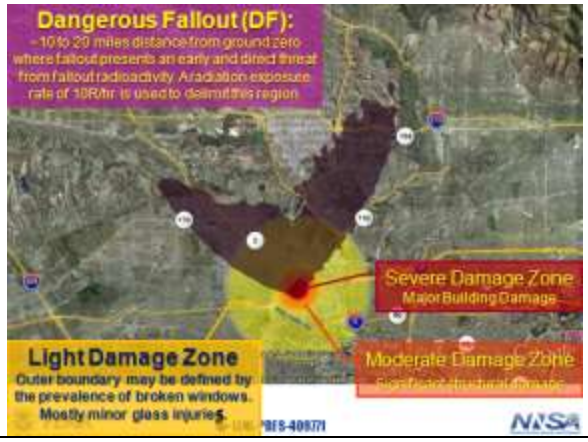
Click –Fallout is not a significant inhalation hazard

Because they are so large, breathing in the particles is not very likely and is a much lower concern than the external exposure from the particles on the ground.

Click –Animation of shelter protection factors begins

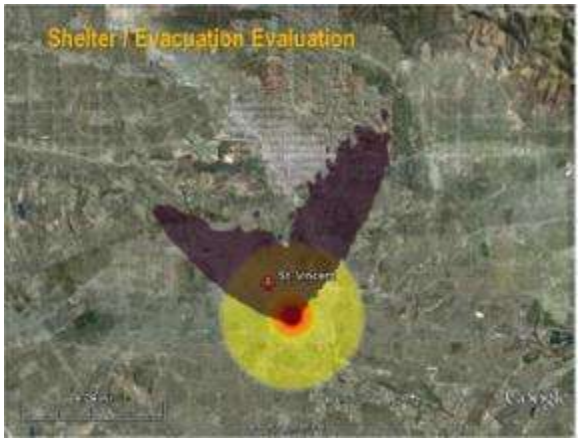
As can be seen by this animation, the particles coat the ground and rooftops. The hazard areas are the ones by the places where the fallout accumulates The radiation



penetrates through windows and walls, but exposure decreases with distance and intervening materials.	
Similar to the SPF of sunscreen; the higher the Protection Factor (PF), the lower the exposure that a sheltered person would receive compared to an unsheltered person in the same area. To obtain the sheltered exposure, divide the outdoor exposure by the PF. This Figure demonstrates presumed protection factors for a variety of buildings and the location within the building. For example, a person top floor or periphery of a ground level of the office building pictured would have a protection factor (PF) of 10 and would receive only 1/10th (or 10%) of the exposure that someone outside would receive. Whereas someone in the core of the building halfway up would have a PF of 100 and receive only receive 1/100th (or 1%) of the outdoor exposure. In fallout areas, knowing locations with adequate protection factors could prevent a potentially lethal exposure.	
Refresher for the 5 Zones • Severe Damage Zone • Moderate Damage Zone • Light Damage Zone • Dangerous Fallout Zone • Hot Zone	

Fallout Exposure Reduction

To help illustrate the type of buildings you would find in a typical L.A. neighborhood, this animation focuses on a neighborhood around the St. Vincent Hospital. For anyone simply standing outside in the first 12 hours following detonation, their dose rate would be 2,000 rem.

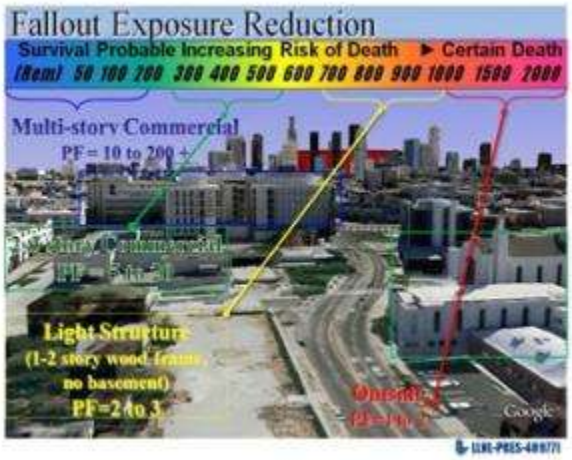


- **Click –Color-coded bar appears**

As you can see, a dose that high would be enough to almost certainly kill you.

- **Click –Light structure range appears**

If the only available shelter was a 1-2 story wood-frame house with no basement, there would still be a reduction in dose. However, at this particular location, it is not enough to prevent a significant exposure.



- **Click -2/3 story commercial structure range appears**

Those seeking shelter in a smaller commercial facility could find protection factors up to 20. People in these types of structures will have survivable exposures.

- **Click –Multi-story commercial structure range appears**

For those who can find shelter in a large, multi-story commercial building, their radiation dose will be so minimal that they may not even experience any acute symptoms from the radiation.

How Many Lives Does It Save?

Sandia National Laboratories conducted an analysis of the potential exposures from a variety of sheltering options for the first 24 hours after the detonation of a 10KT. These are only fallout injuries outside of the moderate damage zone.

If everyone in this area just stood outside for the first 24 hours, ~280,000 people would receive enough radiation exposure to either make them sick (yellow / orange) or kill

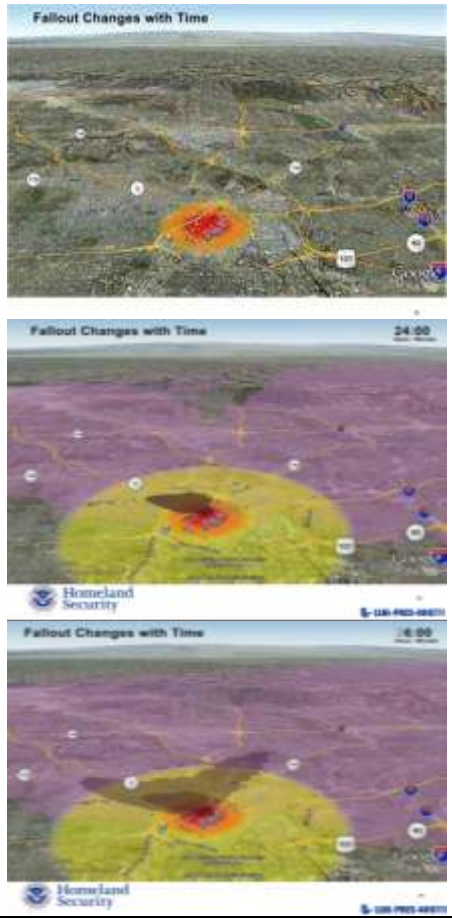
them (red). **Click –PF 3 highlighted PF=3** Even if everyone went into an inadequate structure like a car or small house, 160,000 people would be saved from significant exposure levels. **Click –PF 10 highlighted PF=10** If everyone goes into a "just adequate" shelter like a shallow basement, 240,000 people (out of 280,000) would be saved from significant exposure. Also, of the 40,000 remaining exposures, they are in the "sick, but not dead" category. This is why PF=10 is considered adequate. **Click –PF 50+ highlighted** Finally, if everyone could get to the core of an office or an underground basement, there would be no significant exposures to deadly radiation levels. **Slide Transition –Animation begins**	

Fallout Changes with Time

This animation demonstrates the fast nature of radiation. For about an hour after the blast, the Dangerous Fallout zone continues to grow and spread.

After about an hour, however, the dangerous area starts to shrink. This is due to the short half-life of many of the radionuclides produced. Even though there will always be some amount of radiation left over, most of the dangerous levels decay quickly.

So the key question is "how long should people remain in their shelter?"



Optimum Shelter/Departure Example

- **Click –Informed evacuation route map appears**

Most people in the Dangerous Fallout zone will likely receive some exposure to fallout; this is unavoidable. However, knowing how long to shelter and the direction to evacuate can significantly lower the exposure.
This example presumes an informed evacuation. In this case the best possible route out of the area is SW down S. Alvarado. Unfortunately the victims in this area would not know that without outside help as other routes (away from the blast to the North and toward the freeway to the East) would look just as viable, but result in much higher evacuation exposures.

- **Click –Church example appears**

This graph shows the total radiation dose received by someone sheltering inside a church with a protection

factor of 10 (90 percent shielding). Dose rates will continue to rise depending on how long the person remains inside the church. **Click –Dose rate during evacuation appears** The orange on the graph represents the additional exposure the person would receive while trying to evacuate the area ***at the time specified***. Notice how high the evacuation dose is if they where to leave in the first hour. That is because they are trying to evacuate while the radiation levels are highest outside. **Click –Total dose rate appears** In this example, by waiting four hours to evacuate (the optimum departure time in this case), the person receives the lowest possible dose of radiation. Although there is an apparent minimum dose around four or five hours, the slight increase of exposure with this is minimal compared with the hazards of early evacuation.	

Optimum Shelter Departure Time Depends on Shelter and Evacuation Route

Click – PF 3 example appears

When to evacuate a shelter depends on how much protection a person is getting from the structure, and how long it will take an average person to complete the evacuation route. Knowing the answer to both of these is crucial to creating informed evacuation routes.

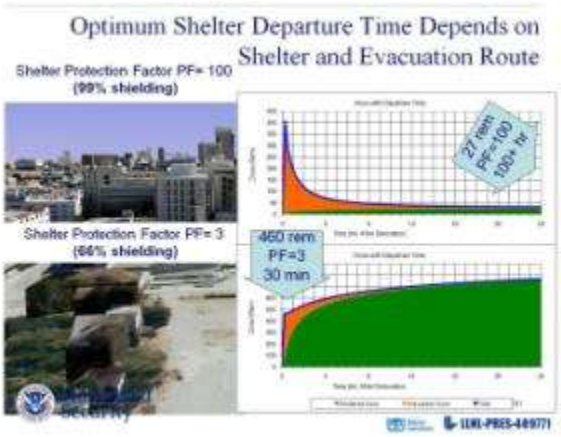
In this example, the wood frame house offers only poor protection. Although it does reduce the outside exposure by a factor of three, it is still not enough to warrant staying in the structure for very long. In fact, if the opportunity arises they should consider moving to a structure like this…

Click – PF 100 example appears

The core of a midrise building, like this hospital, or an underground parking garage, can easily offer protection factors of 100 or more.

In these environments almost all of the exposure occurs during the evacuation and it is best to wait as long as possible before evacuating. In this example, three days or more is the optimal evacuation time.

Again, whether you wait for 12 hours or three days, the difference in exposure is slight compared to the dangerous evacuation doses you would receive in the first few hours.



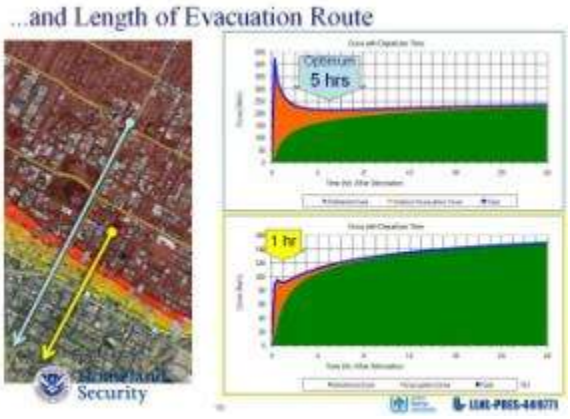
Optimum Shelter Departure Time Also Depends on the Length of the Evacuation Route

It is also important to consider how long it will take an average person to evacuate using the planned evacuation route.

In this example of two identical buildings with a protection factor of 10, the one closer to the edge of the dangerous fallout zone should evacuate earlier because their overall evacuation exposure is less.

In this example, the optimal evacuation for the location near the edge of the DFZ is one hour, whereas the same protection factor building closer to the center of the DFZ should wait for five hours.

This is why rapid hazard zone assessment is important as it drives a number of potential exposure lowering strategies.



Early, adequate shelter followed by informed, delayed evacuation

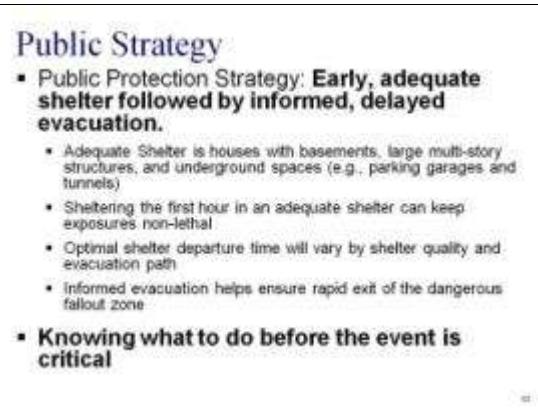
Click –Public Protection Strategy appears

Public Protection Strategy: Early, adequate shelter followed by informed, delayed evacuation. This includes:

- Adequate shelter includes houses with basements, large-multi-story structures, and underground spaces like parking garages or tunnels
- Sheltering the first hour in an adequate shelter can keep exposures non-lethal
- Optimal shelter departure time will vary by shelter quality and evacuation path
- Informed evacuation helps ensure rapid exit of the dangerous fallout zone

Click –Knowing what to do before the event is critical

By having response plans in place, and knowing where the best shelter is, many lives can be saved.



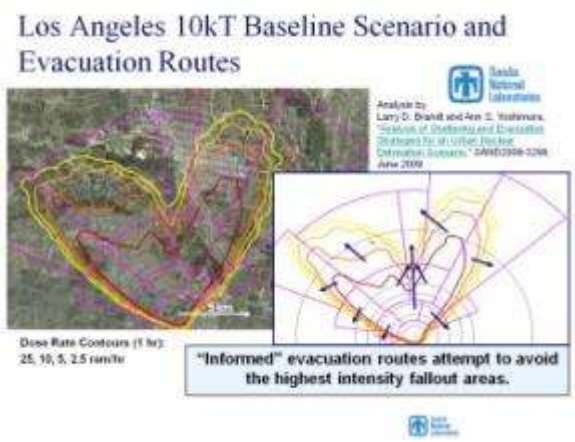
5- Shelter/Evacuation Assessments

L.A. 10 KT Scenario

Following detonation of a 10 KT detonation in Los Angeles, informed evacuation routes would be created based on weather conditions, wind speed and structural considerations.

Sandia National Laboratory divided the fallout area into a number of zones to establish an overall evacuation dose assessment. Based on the fallout patterns after one hour, many different evacuation routes are possible. After determining routes, it is important to have a plan in place to communicate these routes to those inside fallout zones.

Having public communication strategies is the key to a successful informed evacuation. This includes a way to broadcast messages to anyone affected by the blast; something that may be difficult if communications equipment is disrupted.



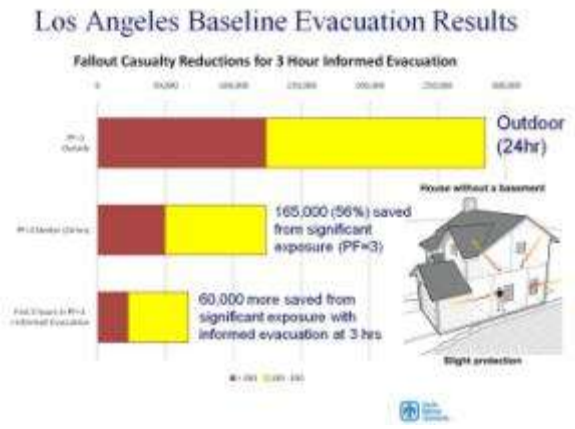
L.A. Baseline Evacuation Results (PF 3 Example)

Again, this analysis only looks at potential fallout victims outside of the MDZ. If everyone in L.A. stayed outdoors for the first 24 hours of exposure, ~ 280,000 people would receive substantial radiation doses.

- **Click –PF 3 results appear**

If residents were to stay in a shelter with a protection factor of three for the first 24 hours, it would be enough to save 165,000 people, or 56 percent of the population, from significant exposure.

- **Click –Informed Evacuation results appear**



If we add an informed evacuation at three hours (so three hours in PF=3 building followed by clear, informed evacuation instructions and routes after three hours) another 60,000 people would be saved from significant exposure.	

L.A. Baseline Evacuation Results (PF 10 Example)

This graph again demonstrates differences in exposure, but uses a protection factor 10 shelter instead.

Just like the previous example, if everyone were to wait outside for the first 24 hours, nearly 280,000 people would have significant exposure to fallout radiation.

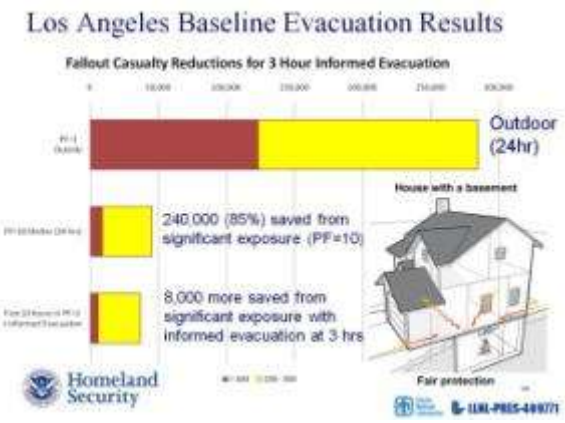
- **Click –House with basement appears**

If all residents were able to get in to an adequate (protection factor 10) shelter, like a shallow basement, apartment building or low rise office building, 240,000 people would be saved from significant exposure.

- **Click –Informed Evacuation results appear**

Even though the protection factor 10 structures offer a great deal of protection, if those same residents were still given informed evacuation plans after three hours, another 8,000 people would be saved from significant exposure.

This example demonstrated why adequate shelter (which saved 240,000 for significant exposure) is more important than informed evacuation.

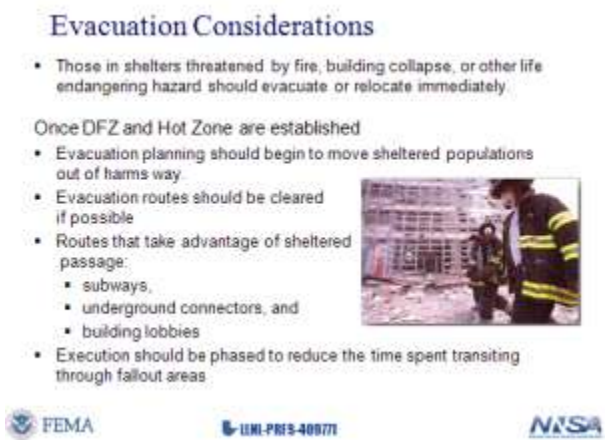


Even during the initial (most dangerous) phases of the event, we need to make sure that we do not have "tunnel vision" regarding the radiation hazard and look at all the life safety issues. In particular, it does no good to shelter from the radiation if your shelter collapses on you or is on fire. Be sure that the public knows that other life threatening hazards can take priority.

AFTER THE DFZ IS ESTABLISHED

Evacuation planning can begin

- Evacuation routes should be cleared if possible
- Routes that take advantage of sheltered passage (subways, underground connectors, through building lobbies) should be used if possible
- Execution should be phased to reduce the time spent transiting through fallout areas



When evacuations are executed, travel should be at right angles to the fallout path (to the extent possible) and away from the plume centerline, sometimes referred to as "lateral evacuation."

For more complex fallout patterns like the one pictured here, ensure that evacuations move people down the length of the fallout pattern or into another fallout contamination area.

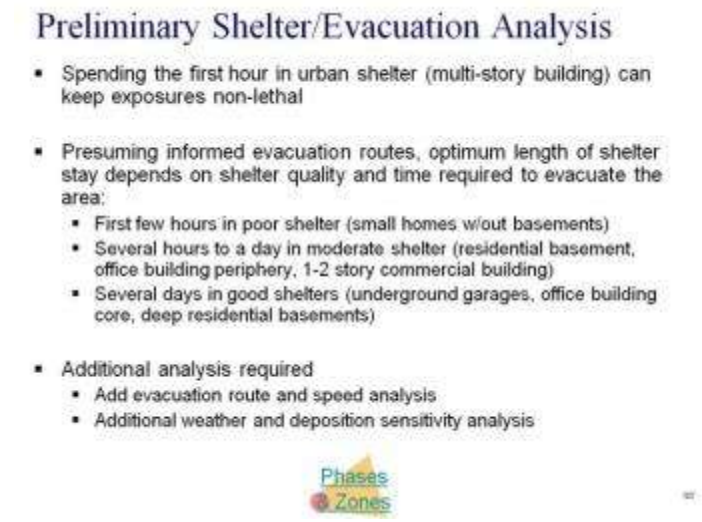
Preliminary Shelter/Evacuation Analysis

- **Spending the first hour in an urban shelter (multi-story building) can keep exposures non-lethal:** for anyone who can seek some type of shelter, their chances of significant, deadly radiation levels is dramatically reduced

- **Presuming informed evacuation routes and optimum length of shelter stay depends on shelter quality and time required to evaluate the area:** based on what type of shelter a person is in, certain guidelines should be followed
  - ✓ First few hours in a poor shelter (small homes without basements)
  - ✓ Several hours to a day in moderate shelters (residential basement, office buildings, small commercial buildings)
  - ✓ Several days in good shelters (underground garages, office buildings, deep basements)

Click –Additional analysis required appears

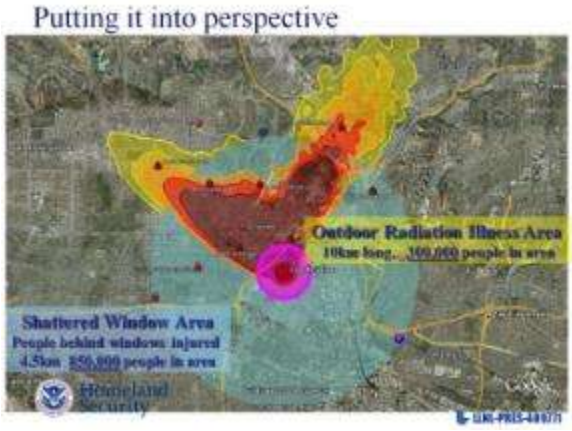
City specific analysis must be performed that takes into account the types of structures and ease of evacuation to be used for planning purposes.



This slide demonstrates the areas that can lead to acute effects, the initial blast zones where there could be injuries from flying glass and debris out to 3 miles, and the dangerous fallout area could extend for 10-20 miles.

Click –Animation begins

As you can see, the areas of potential injury are small when compared to the resources of the area. While it will still be devastating, it is not the "nuclear end-all" situation that many people envision when they think about a nuclear bomb and there are a lot of resources in the surrounding



area that can safely help save and sustain lives… If they know what to do!

Weather Matters

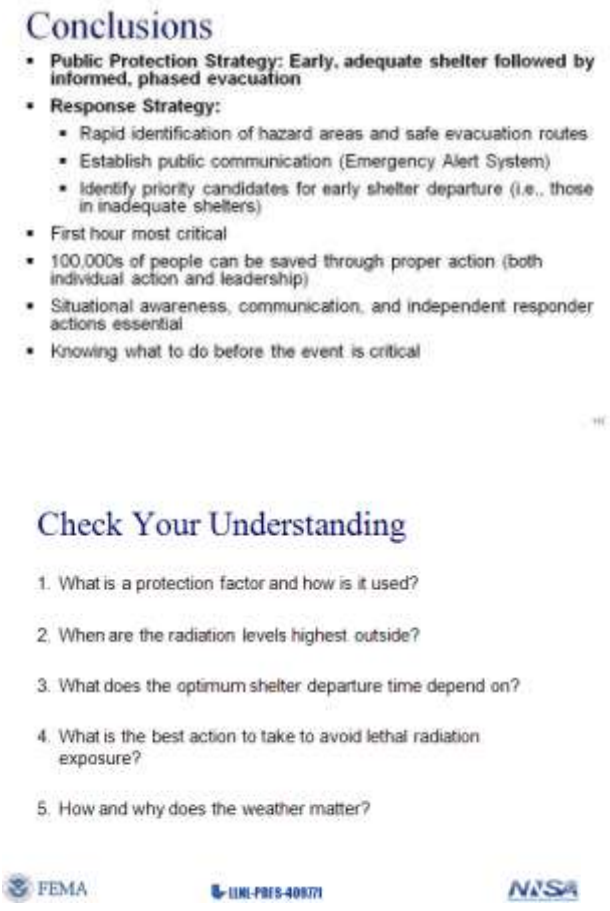
No IND response can be completely preplanned. Weather and yield will greatly affect the direction, extent, and shape of the fallout pattern. As can be seen by the following animation, which demonstrated the fallout pattern from a 10KT modeled using weather from the 15th of each month in 2006,

Click –Animation begins

these effects can by highly variable.

- **Public Protection Strategy: Early, adequate shelter followed by informed, phased evacuation** – With planning, residents can be aware of the dangers of a nuclear detonation, as well as what to do if it happens. People can be made aware that seeking an adequate shelter and waiting for evacuation instructions can save their lives.

- **Response Strategy**:
  Rapid identification of hazard areas and safe evacuation routes – being able to quickly know where the Dangerous Fallout Zone is, and the best routes based on that, is key to saving lives
  ✓ *Establish public communication (Emergency Alert System)* – reestablishing emergency communication channels and immediately broadcasting safety messages is important to public safety
  ✓ *Identify priority candidates for early shelter departure* – residents in inadequate shelters should be given priority when planning evacuation routes, as they will need to begin evacuation first to avoid lethal doses



• **First hour most critical –** residents need to know to immediately seek shelter • **100,000s of people can be saved through proper action –** having informed evacuation plans in place will save many people from significant radiation doses • **Situation awareness, communication and independent responder actions is essential –** knowing what do when an IND detonates is important and will save lives • **Knowing what to do before the event is critical –** having response plans, knowledge about fallout, and training will save countless lives after an IND detonation	