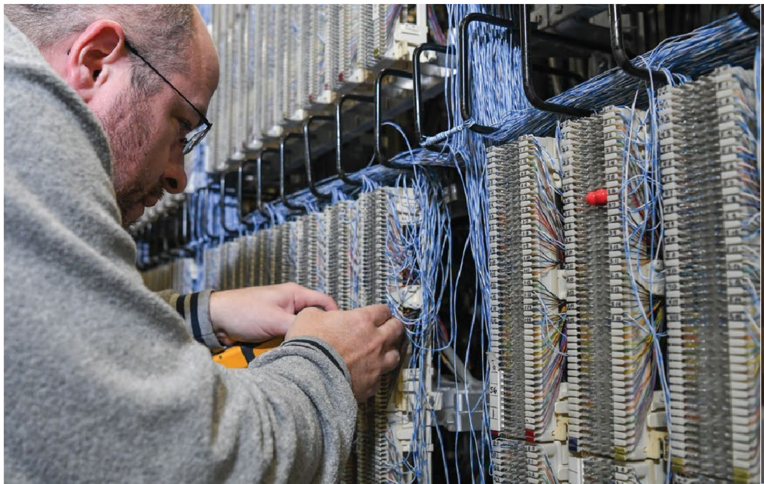

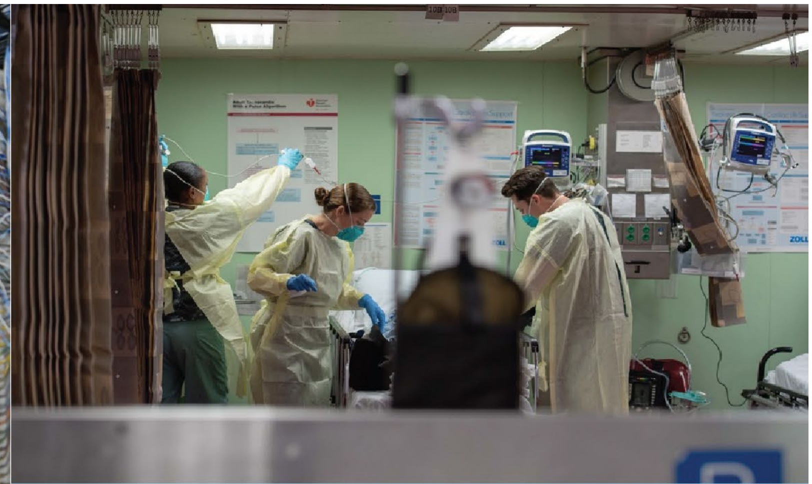

Planning Guidance for Response to a Nuclear Detonation

Third Edition

May 2022

U.S. DEPARTMENT OF HOMELAND SECURITY
FEMA

This guidance was developed by a federal interagency committee led by the Federal Emergency Management Agency (FEMA) Chemical, Biological, Radiological, and Nuclear (CBRN) Office with representatives from the Department of Homeland Security (DHS) Science and Technology Directorate (S&T), the Department of Energy (DOE), the Department of Health and Human Services (HHS), the Department of Defense (DoD), and the Environmental Protection Agency (EPA). Future editions and interagency interaction related to Planning Guidance for Response to a Nuclear Detonation will be coordinated by FEMA.

Please refer comments and questions to the FEMA CBRN Office (www.fema.gov/about/offices/chemical-biological-radiological-and-nuclear).

Foreword for Third Edition

The First Edition (2009) of this planning guidance focused on a small nuclear detonation at ground level in an urban environment—specifically, National Planning Scenario (NPS) #1.[1] The Second Edition (2010) provided updated terminology, added the concept of the Hot Zone (HZ), and added a chapter specifically to address public preparedness and emergency public communications in the post-detonation environment.

The Third Edition (2022) has been updated and expanded to provide guidance for a wider range of nuclear detonations, including larger detonations and air bursts. It also incorporates new research, best practices, and response resources. Additionally, this edition includes a new chapter on the Integrated Public Alert & Warning System (IPAWS), which enables state, local, tribal, and territorial (SLTT) officials to send warnings and key messages during the response.

[1] To access National Planning Scenario (NPS) #1, visit www.fema.gov/txt/media/factsheets/2009/npd_natl_plan_scenario.txt.

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Acknowledgments

The FEMA CBRN Office gratefully acknowledges the guidance and support provided by the Department of Energy (DOE) and the National Labs, the Department of Health and Human Services (HHS), the Department of Homeland Security Science and Technology Directorate (DHS S&T), the Centers for Disease Control and Prevention (CDC), the Environmental Protection Agency (EPA), the Department of Defense (DoD), and other FEMA offices.

Introduction

If a nuclear detonation occurred in an American city, it would be one of the most catastrophic incidents the United States (US) has ever experienced. Responders must be prepared to address the unique challenges of a nuclear incident response. With careful planning, many lives can be saved and injuries mitigated. Additionally, preparing and planning for nuclear detonations better equips your community for other natural and man-made hazards/disasters, such as fire-spread, hurricanes, earthquakes, and radiological incidents.

While the fallout hazard is unique, most aspects of multi-hazard or all-hazard planning and response are applicable to nuclear detonation response and planning. Planners and responders bring a wealth of experience and expertise relevant to nuclear detonation response. This guidance provides nuclear detonation information and context to enable planners, responders, and their leaders to leverage their existing capabilities.

Specifically, this document describes the considerations, planning factors, and available resources to craft a successful nuclear detonation response plan. This document focuses on the first 24 to 72 hours after a detonation, when early actions can save many lives.

The primary audiences for this planning guidance are federal, state, local, tribal, and territorial (FSLTT) emergency response planners at all levels and their leadership. The target audiences for this document include, but are not limited to:

- Emergency managers
- Law enforcement authority planners
- Fire response planners
- Emergency medical service planners
- Hazardous material (HAZMAT) response planners
- Utility service and public works emergency planners
- Transportation planners
- Public health planners
- Medical provider planners (e.g., hospitals)
- Mass care providers (e.g., American Red Cross)
- Public information officers (PIOs)

- Local and regional private sector industries capable of providing logistical support for the immediate response—either by voluntary actions or by requisition of resources.
- Other emergency planners, planning organizations, and professional organizations that represent disciplines that conduct emergency response activities.

This guidance was developed by a federal interagency writing team led by the FEMA CBRN Office. The guidance could not have been completed without the technical assistance provided by agencies and organizations summarized in the Acknowledgements section. This planning guidance underwent extensive stakeholder review, including federal interagency and national laboratory subject matter experts (SMEs); emergency response community representatives from police, fire, emergency medical services; medical providers; and professional organizations, such as the Health Physics Society and the Interagency Board.

This guidance also reflects evolving nuclear threats. The 2010 Planning Guidance focused on 10 kiloton (kT) and smaller-yield detonations consistent with the threat of nuclear terrorism, all occurring at the Earth's surface. This 2021 Planning Guidance update addresses an expanded range of threat scenarios, including nation-state threats[2] with much larger explosive yields. This guidance also considers nuclear devices delivered by ballistic missile or aircraft that can deliver detonations elevated above the surface. Low-altitude air bursts can increase the scale of the blast and thermal damage inflicted but may also significantly reduce local fallout impacts. Urban emergency planners should focus on surface and low-altitude detonations because these detonations will have the greatest effect on an urban environment.

The technical community that developed Chapter 1 and Chapter 2 of this guidance was tasked to address how these expanded threat factors shape the resulting guidance for emergency response planning.

[2] Nation-state threats are threats from other countries or nation-states. As countries are typically larger, more organized, and better funded than non-state groups, the threats from these countries are generally more sophisticated.

Structure of This Document

For planners with specific specialties or authorities, Chapters 3 through 7 are each designed to be pulled out and, when combined with Chapters 1 and 2, form stand-alone guidance documents. For example, if a planner is only responsible for early medical care, covered by Chapter 4, they would only need Chapters 1, 2, and 4. Appendices for each chapter are numbered based on the chapter they related to. For example, Appendix 2.1 and Appendix 4.3 correspond to chapters 2 and 4, respectively.

In each section and chapter, key opportunities to act, coordinate with other governments or agencies, reference external materials, and think critically are highlighted. These opportunities take one of four forms, described below:

Action Item

A suggested activity for the planner to complete.

Coordination Opportunity

An interagency or interorganizational coordination opportunity. Making these connections during planning can simplify coordination during response.

Refer To

References to additional information in separate resources.

What Would You Do?

A critical thinking exercise or discussion question. These questions highlight unique aspects of nuclear response.

Critical Considerations

- The immediate federal response will involve modeling, coordination, mobilization, public communication (Chapter 6), and alert, warning, and notification (Chapter 7). However, it is unlikely that significant federal response assets will arrive on-scene for 24 hours, and the full extent of federal assets will not be available for several days. Emergency response is principally a local function and, for purposes of this document, no significant federal on-scene response is assumed for 24–72 hours.

- Based on technical analyses and modeling, recommendations are intentionally simplified to maximize their utility in uncertain situations where technical information is limited.

Radiation Units

Roentgen, Rad, & Rem

This document uses units familiar to U.S. audiences and emergency responders:

- roentgen (R): The unit of ***exposure*** associated with gamma or x-rays in air. This is the most common unit of measurement for US emergency response equipment, often expressed in mR. 1,000 milli-roentgen (mR) = 1 roentgen (R).
- roentgen per hour (R/h): The unit for ***exposure rate*** associated with gamma or x-rays in air, exposure per unit of time.
- rad: The unit associated with the ***absorbed dose*** of ionizing radiation. Absorbed dose is the energy deposited per unit mass of matter (e.g., tissue). The international unit for absorbed dose is the gray [Gy] and the conversion is 1 Gy = 100 rad.
- rem: The unit that adjusts the absorbed dose for the biological effectiveness of ionizing radiation in tissue to express the long-term risk of cancer (also called dose equivalent). The international unit is the sievert [Sv] and the conversion is 1 Sv = 100 rem.

For ***external gamma radiation from fallout***, the following approximation can be used:

$$1\,\mathrm{R} \approx 1\,\mathrm{rad} \approx 1\,\mathrm{rem}$$

Radiation can be measured in a variety of ways. There are four different but interrelated units for measuring radioactivity, exposure, absorbed dose, and dose equivalent. These can be measured with both traditional (British, e.g., Ci) and international (SI) (metric, e.g., Bq) units in use:

Table 1: Radiation Measurement Units

	Traditional Units	SI Units
Radioactivity	curie (Ci)	becquerel (Bq)
Exposure	roentgen (R)	coulomb/kilogram (C/kg)
Absorbed dose	rad	gray (Gy)
Dose equivalent	rem	sievert (Sv)

Table 2: Traditional/SI Unit Conversions

1 curie	3.7x1010 becquerel (Bq)= 3.7x1010 disintegrations/second
1 rad	0.01 gray (Gy) or 1 centigray (cGy)

1 rem	0.01 sieverts (Sv)
1 roentgen (R)	0.000258 coulomb/kilogram (C/kg)
1 gray (Gy)	100 rad
1 sievert (Sv)	100 rem

Narrative

This narrative is a fictional depiction of how a nuclear detonation might unfold in a modern US city. The intention is to emphasize that preparedness is achievable and can save many lives.

Fire Chief Sophia, Fire Station 52, 2 Miles from Metropolis City Center, 9:00AM (T + 0 min)

The flash completely blinded Sophia as she drove out of the firehouse after her shift—her entire field of vision was bright white. She quickly braked and heard other vehicles doing the same. Still, her car lurched to the left with the sound of a low-speed impact.

Her hands, neck, and face felt like they were on fire, and she ducked below the dashboard instinctively. Just as her vision started to return, she heard an overwhelming sound, her windows cracked, and her car lurched again.

Emergency Planner Jayden, City Emergency Operations Center (EOC), 10 miles from Metropolis, 9:00AM (T + 0 min)

Metropolis's watch center was a small, windowless room on the third floor of the City Emergency Management Agency building. Dozens of television screens illuminated the walls, and the chatter of first-responder radio broadcasts saturated the air.

Suddenly, the lights flickered, the televisions went to static, and the radio chatter went silent. Seconds later, the televisions and radios came back, with loud exclamations: "Do you see that?" and "That is BRIGHT."

"Get City Hall on the phone and find out what's going on—I'm calling the state EOC," Jayden heard the watch center supervisor order. Equipment lacking backup power briefly went dead before emergency generators kicked in for essential systems. Almost a minute after the initial disturbance, the entire room suddenly shook, as if a truck had slammed into the building.

"I'm going to take a look outside," Jayden announced to the room. As Jayden ran down the hall, he noticed confused co-workers peering out partially shattered windows. Stepping out onto the balcony, Jayden saw a massive column of smoke rising over the horizon above Metropolis.

Refer To

Chapter 1: Nuclear Detonation Impacts for information about immediate impacts, such as flash blindness and electronic equipment effects.

Fire Chief Sophia, Fire Station 52, 2 Miles from Metropolis, 9:05AM (T + 5 min)

After about a minute, the fire chief's vision and hearing had mostly returned. Seeing no immediate danger, she stumbled to check on the other driver and confirmed he was okay. Looking around, the chief was confused—her vehicle was not on fire, but she had felt like she was getting burned moments ago.

A large cloud hung over the city center, but it looked strange—way too big to move that fast. It was red, black, and brown, but unlike the fire smoke plumes she was familiar with. Piecing together the information, she suddenly understood and ran back to the firehouse.

When she arrived, the station's backup lights were on. She attempted to call dispatch, but the landline was dead and her cellphone had no signal. She could hear chatter through her 800 MHz radio about a nuclear detonation and tried to respond with her shoulder mic, but the radio failed to transmit. She restarted the radio and tried again, "This is the Chief from Station 52. We can hear you," she successfully transmitted. "We're assuming this was a nuclear detonation and operating according to our protocol: We will be sheltering at the station, monitoring radiation levels with our detection equipment, avoiding outdoor operations unless exposure rates are below 10 mR/hr, and updating the city's EOC with our status every 30 minutes. Be advised, roadways in our area are impassable due to a traffic jam involving a large number of accidents."

The fire chief knew that there were two immediate hazards after a nuclear detonation— fallout and fire. The best protection from fallout is to shelter, but the best strategy for evolving fires is to evacuate. A white cloud top would indicate minimal fallout, but a dark cloud, like the one she saw, likely means significant fallout levels (see Chapter 1, Figure 12). Her fears were confirmed as radio chatter indicated that firehouses on the other side of town were seeing high radiation levels.

Emergency Planner Jayden, City EOC, 10 miles from Metropolis, 9:05AM (T + 5 min)

After Jayden returned to the watch center and explained what he saw, his supervisor announced, "Per our public warning protocols, if we suspect a nuclear detonation, we must immediately distribute a shelter-in-place (SIP) warning. We have the pre-scripted message ready to send to every cellphone, radio, and news station within 50 miles of Metropolis, but we need sign-off from the front office. Unfortunately, city and county leadership were at the event downtown, and neither are answering the phone."

The agency's Public Information Officer (PIO), responded, "The protocol allows flexibility if agency executives are unavailable—you and I can sign-off. We have to do this now."

Refer To

Chapter 6: Communications and Public Preparedness for information about developing message dissemination plans.

Leveraging FEMA's Integrated Public Alert & Warning System (IPAWS) network, as well as the city's own opt-in emergency communication service, the watch office distributed an emergency SIP message to everyone within 50 miles of Metropolis. The Wireless Emergency Alert (WEA) message, distributed to cellphones, read: “This is a message from Metropolis Emergency Management Agency: a nuclear detonation has occurred. To protect yourself and your family, get inside, stay inside, stay tuned for more information. Move to the lowest level/most interior portion of the building if possible. Follow instruction from officials—this can save your life.”

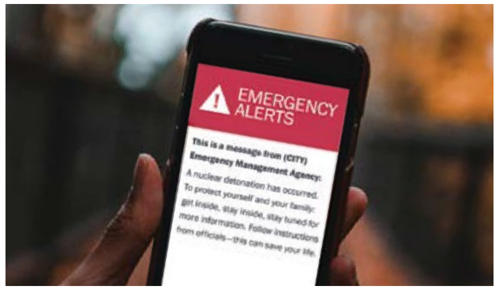

Figure 1: WEA message on a cellphone reads “This is a message from Metropolis Emergency Management Agency: a nuclear detonation has occurred. To protect yourself and your family, get inside, stay inside, stay tuned for more information. Follow instruction from officials—this can save your life.”

Over the next few minutes, several more WEA messages came through—but not from the City Watch Office. Two came from neighboring counties, one from the state EOC, and yet another from the White House. Every message said the same thing: “Get Inside, Stay Inside, Stay Tuned.”

Refer To

Chapter 7: Alerts, Warnings, Notifications and FEMA’s Integrated Public Alert and Warning System (IPAWS) for information about IPAWS and WEA messaging.

PIO Jose, State Joint Information Center (JIC), 50 miles from Metropolis, 9:15AM (T + 15 min)

Jose’s phone buzzed when he received the emergency alert from Metropolis’ EOC. The state EOC was officially sheltering in place since they were just 50 miles from Metropolis. Metropolis’ watch center messages made it out just before the state JIC was activated, but the message was aligned with the JIC plan because they were using the same communication plan and preapproved messages.

Jose immediately initiated the phone tree to mobilize his PIO staff. He sent the draft message: “A nuclear event has occurred in Metropolis. If you are within 50 miles, get inside a basement or central room of any nearby building, stay inside, stay tuned for more information. Do not leave your shelter unless officials provide other instructions, or your shelter is threatened by fire or collapse.”

Jose quickly checked his email and saw a message from the lieutenant governor: “FEMA confirmed a nuclear detonation in Metropolis.” Jose quickly sent a message to his media contacts confirming the detonation, reminding them to disseminate the “Get Inside, Stay Inside, Stay Tuned” message. He attached the media guide his team had built to answer common safety and technical questions and pressed send.

Emergency Planner Jayden, City EOC, 10 miles from Metropolis, 12:00PM (T + 180 min)

Three hours after the detonation, Jayden was staffing the Situation Unit in the city's EOC. Their task was to receive, aggregate, and map impact reports from the entire city every 30 minutes. Due to limited operating communication infrastructure in the blast area, most information came from facilities that were equipped with radios, such as firehouses, police precincts, and hospitals. The internet was too unstable for the EOC to use their online systems, so the Situation Unit resorted to manual entry into offline spreadsheets and geographic information system (GIS) programs.

For the time being, radio-only communication was a bottleneck, so the information they collected had to remain simple. It included reports on casualty triage, blast damage, fires, and radiation exposure rates. Occasionally, facilities reported their status and resource needs, and this information was relayed to the appropriate Emergency Support Function (ESF) coordinator in the EOC.

Over time, it became clear that the heaviest damage was in a roughly mile-wide area around Metropolis' city center. No information was available within a half-a-mile radius. Though rapid fallout decay caused exposure-rate reports to vary significantly, it was very clear that most fallout material settled north of the city.

Fire Chief Sophia, Fire Station 52, 2 Miles from Metropolis, 12:25PM (T + 205 min)

Radiation readings outside were elevated at a few milliroentgen per hour (mR/hr), but well below the 10 R/hr that would require Sophia's crew to remain sheltered. Station 52 was south of the detonation, and since the city EOC reported that fallout went north, Sophia knew she was able to act.

People with injuries had been arriving at the firehouse since the explosion, mostly with non-life-threatening injuries like cuts and bruises from flying/falling glass and debris. Sophia put her paramedic in charge of setting up a triage station and moving serious casualties to the care center at the hospital a few miles south.

Using her rig to clear a path, Sophia took the rest of her crew northward into the Moderate Damage Zone (MDZ), keeping an eye out for fires. Eventually the road became impassable, and she left the rig near a hydrant and put down lines for fire defense to aid affected people and establish an evacuation corridor.

Refer To

Chapter 4: Acute Medical Care for information about likely casualties and how to triage and treat various injuries.

Her crew made headway into the MDZ until she could see almost complete destruction ahead and radiation levels approached dangerous levels. She knew that ahead lay the severe damage zone (SDZ) where her crew would not be able to safely enter and the possibility of viable survivors was low.

Refer To

Chapter 2: A Zoned Approach for information about various zones, including the MDZ and SDZ.

She could see several fires but did not have the resources to put them all out. She ordered her crew to prevent fire spread when possible and protect the evacuation corridor they had established.

She knew the buildings around her were probably filled with sheltered people, many of whom were likely injured by the blast. She did not have the time or resources to perform building by building search and rescue operations, and fires were spreading and coalescing in the area. She raised her bullhorn and said, “This is Metropolis Fire Department—if you can hear this, please proceed toward the sound of my voice. This area is not safe, and you must evacuate.”

Refer To

Chapter 3: Shelter & Evacuation for information about sheltering and evacuating various populations.

Emergency Planner Jayden, City EOC, 10 miles from Metropolis, 1:00PM (T + 240 min)

Jayden received communication from the state EOC that FEMA and the state government established a joint Initial Operating Facility (IOF) at a convention center outside the city. The IOF was tasked with developing a common operating picture (COP) of the detonation impacts and emergency response activities, and the city EOC would be included in the upcoming call.

The call included representatives from the state EOC, city EOC, FEMA’s Incident Management Assistance Team (IMAT), the Interagency Modeling and Atmospheric Assessment Center (IMAAC), and a few neighboring jurisdictions. The state EOC and FEMA staff explained that they had considerable data from federal assets and counties near Metropolis, but almost nothing from the city itself. They were relieved to receive the data the city had been collecting from responders in Metropolis, and immediately began merging it with regional data and IMAAC models. The responders had been collecting data utilizing paper, radio calls, and the RadResponder mobile application until cell or Wi-Fi signal returned.

Since both the city and state nuclear detonation plans employed the same zone-based response framework, they agreed on a few things immediately. Firstly, no operations would occur in the SDZ. Also, both responders and the public would be urged to continue sheltering indoors if in/near areas where radiation levels were immediately hazardous to health (the Dangerous Radiation Zone [DRZ]). It was clear that lifesaving operations, such as search and rescue and medical triage and treatment, would be prioritized in the MDZ, where the majority of severe injuries were being reported. Finally, roadways were blocked and power was out regionally; therefore, restoration of critical infrastructure was an immediate priority.

The state and federal government were still mobilizing to support the city's response, but adjacent jurisdictions were supporting response activities by preparing to accept evacuees, provide contamination screenings and decontamination, expand medical care resources, and send first-response assets. Over the next 72 hours, a considerable amount of resources would be arriving from across the nation to support the city and state, but the city itself was primarily responsible for executing the immediate response.

Refer To

Chapter 5: Population Monitoring for information about contamination screening.

1. Nuclear Detonation Impacts

The descriptions and planning factors provided in this document are nominally based on the Department of Homeland Security (DHS) National Planning Scenario (NPS) #1, which describes a 10 kiloton (kT) yield nuclear detonation at ground level in an urban environment. This document captures a wider range of potential planning considerations, describing the impacts of smaller and larger yields, as well as detonations that occur above ground (see Table 3).

Table 3: Planning Guidance Scenarios

Yield	Height Above Ground
0.1 kT	Ground burst
1.0 kT	Ground burst
10 kT	Ground burst
100 kT	Ground burst
100 kT	Air burst, 1000 ft
100 kT	Air burst, 5000 ft

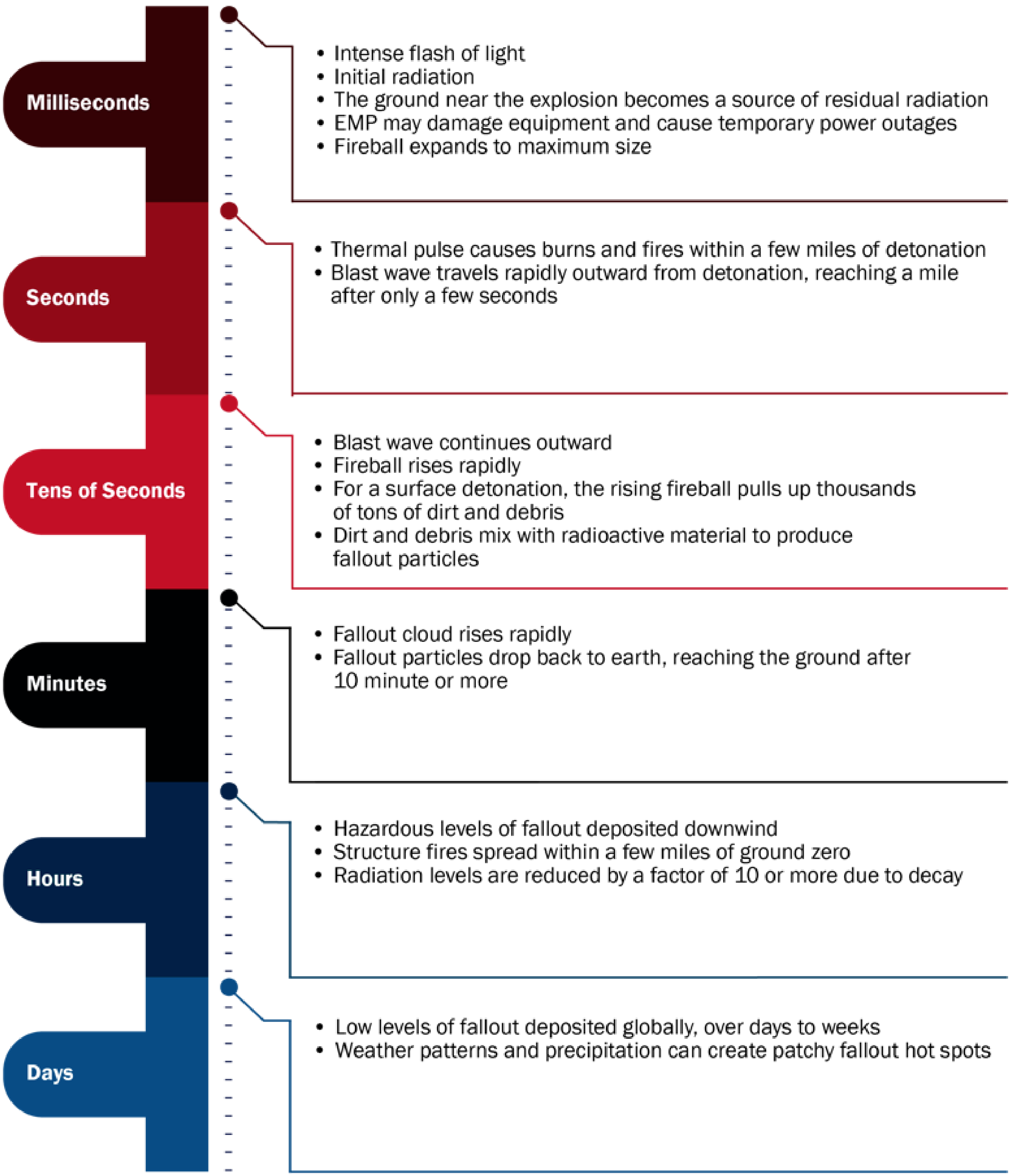

Figure 2: Timeline of key effects for a 10 kT surface detonation. (Topics defined and/or described in this figure are described in more depth in the following text.)

Nuclear detonations release intense light, a pulse of heat and radiation, and a blast wave. In many circumstances, additional effects include residual radiation in the form of fallout and an electromagnetic pulse.

What are detonation yields?

Even a small nuclear detonation produces an explosion far surpassing that of conventional explosives. It would take 1,000 tons of TNT to release the same energy created by the fission of all the atoms in just 2 ounces of uranium.

The magnitude, or yield, of a nuclear explosion is quantified in terms of the equivalent amount of TNT (a chemical explosive) it would take to create the same energy release. It is usually expressed in the thousands of tons (kT) of TNT. Therefore a 1 kT nuclear device would produce an explosive yield equivalent to 1,000 tons of TNT. For comparison, this is the approximate amount of energy released in the 2020 Beirut ammonium nitrate port explosion (Rigby, 2020).

- **A brilliant flash of light** occurs at the moment of detonation (for aboveground detonations), causing temporary blindness, called flash blindness or dazzle, up to 10 miles away.

- **Radiation** is one of the key outputs from a nuclear explosion. Radiation from a nuclear explosion is categorized as either initial radiation, which occurs within the first minute, or residual radiation, which remains after the explosion. Initial radiation occurs within the first minute after a nuclear explosion and contributes to casualties up to about a mile from the detonation. Residual radiation consists of activated materials[3] near the detonation location and nuclear fission products[4] that may produce long-range fallout.

- **An electromagnetic pulse (EMP)** is generated by the initial nuclear radiation. Although not a direct physical hazard to people, EMPs can disrupt or damage some electronic equipment within a few miles. For low-altitude bursts, the EMP can cause disruptive power surges on power lines within a few miles of the detonation and induce cascading disruptions miles from the detonation site.

- **The fireball** is a luminous sphere of extremely hot gases (tens of million degrees) that forms a few thousandths of a second after a nuclear explosion. The fireball from a 10 kT detonation will reach approximately ¼ mile in diameter and give off a thermal pulse of intense heat within the first few seconds. The high intensity of the thermal pulse differentiates nuclear from chemical explosions.

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[3] The absorption of neutron radiation by soil and other surface material in the immediate vicinity of ground zero creates radioactive material, some of which may be undisturbed by the blast and some of which may be disturbed by the blast and contribute to radioactive fallout downwind.

[4] Nuclear fission products are the atomic fragments left after a large atomic nucleus (like uranium) undergoes nuclear fission by splitting into two smaller nuclei that are most often radioactive.

- What follows depends on the height of burst above the ground.
  - Near-surface[5] detonations will sweep up thousands of tons of dirt and debris that will mix with radioactive products, then "fall out" of the cloud as radioactive fallout particles. Fallout can create dangerous radiation levels downwind of the detonation. Sheltering in downwind areas can potentially save hundreds of thousands of people from significant radiation exposure.
  - An air burst nuclear detonation decreases the risk of fallout but increases the severity of the intense thermal pulse, inducing fires within a few miles of the detonation. Large urban fires can be a significant threat to survivors in the damage zones and evacuation may be required to save lives in this area.
- The rapidly expanding fireball also generates a blast wave. The blast wave moves outward, initially faster than the speed of sound and then slowing down as it radiates outward. For those beyond a few miles, there will be several seconds between the flash of light and the arrival of the shockwave. For those even further away, the blast wave can still break windows and take tens of seconds to arrive.

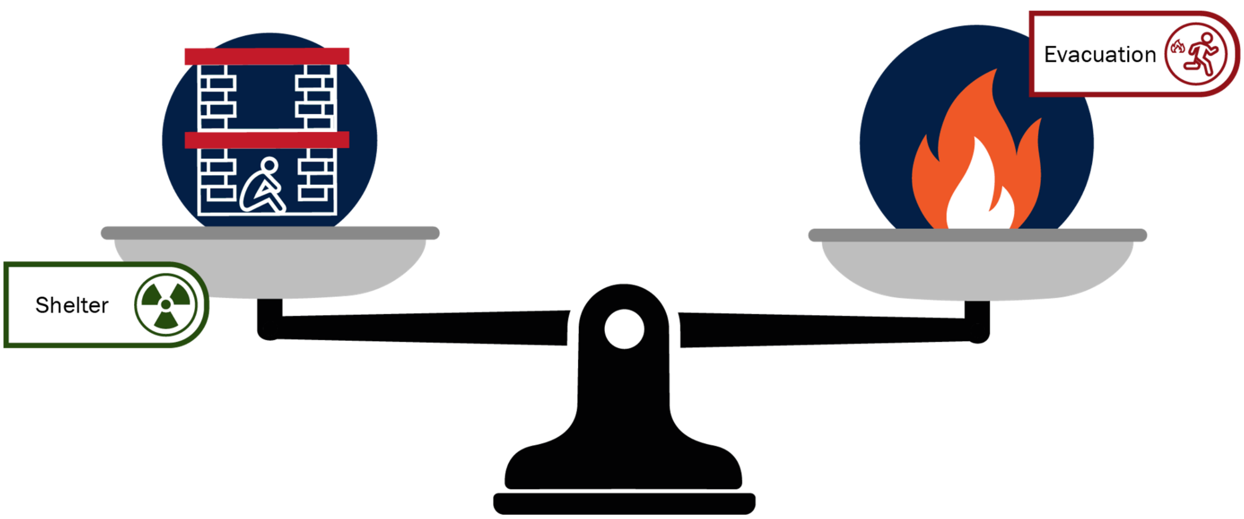

Figure 3: While radiation risks can be avoided by sheltering, evacuation may be necessary to avoid fire risks. Planners and emergency managers must balance these risks.

[5] This document defines near-surface detonations as those where the fireball interacts with the surface of the Earth.

Refer To

Videos of nuclear detonations are available here: www.llnl.gov/news/llnl-releases-newly-declassified-test-videos.

1.1. Blast

A primary effect of a nuclear detonation is the blast wave generated by the rapidly expanding fireball. Blast is often measured by the overpressure[6] it produces.

Near the detonation, overpressure is extremely high (thousands of pounds per square inch [psi]) and expands in all directions from the detonation, initially faster than the speed of sound. Beyond a few miles, the blast wave will traverse about a mile every five seconds. This may allow a few seconds for those who observe the flash to take cover and reduce injury from flying debris.

1.1.1. DAMAGE ZONES

Structural damage can be used to describe zones for response planning, where each zone has different response priorities and survival implications. Blast damage mechanisms and the area impacted in each zone vary based on terrain, building density, and atmospheric conditions. As such, blast damage zones will be primarily determined by visual observations of damage.

The purpose of establishing zones is to help planning response operations and prioritizing actions. Models can provide initial zone estimates for planning, though actual zone areas and boundaries will not be as clearly defined as model results imply. Many of the graphics in this document do not have sharp boundaries, reinforcing expected uncertainty and variability. The blast zones depicted below are for a 10 kT ground burst nuclear explosion in an urban environment.

[6] Pressure over and above atmospheric pressure, measured in pounds per square inch (psi).

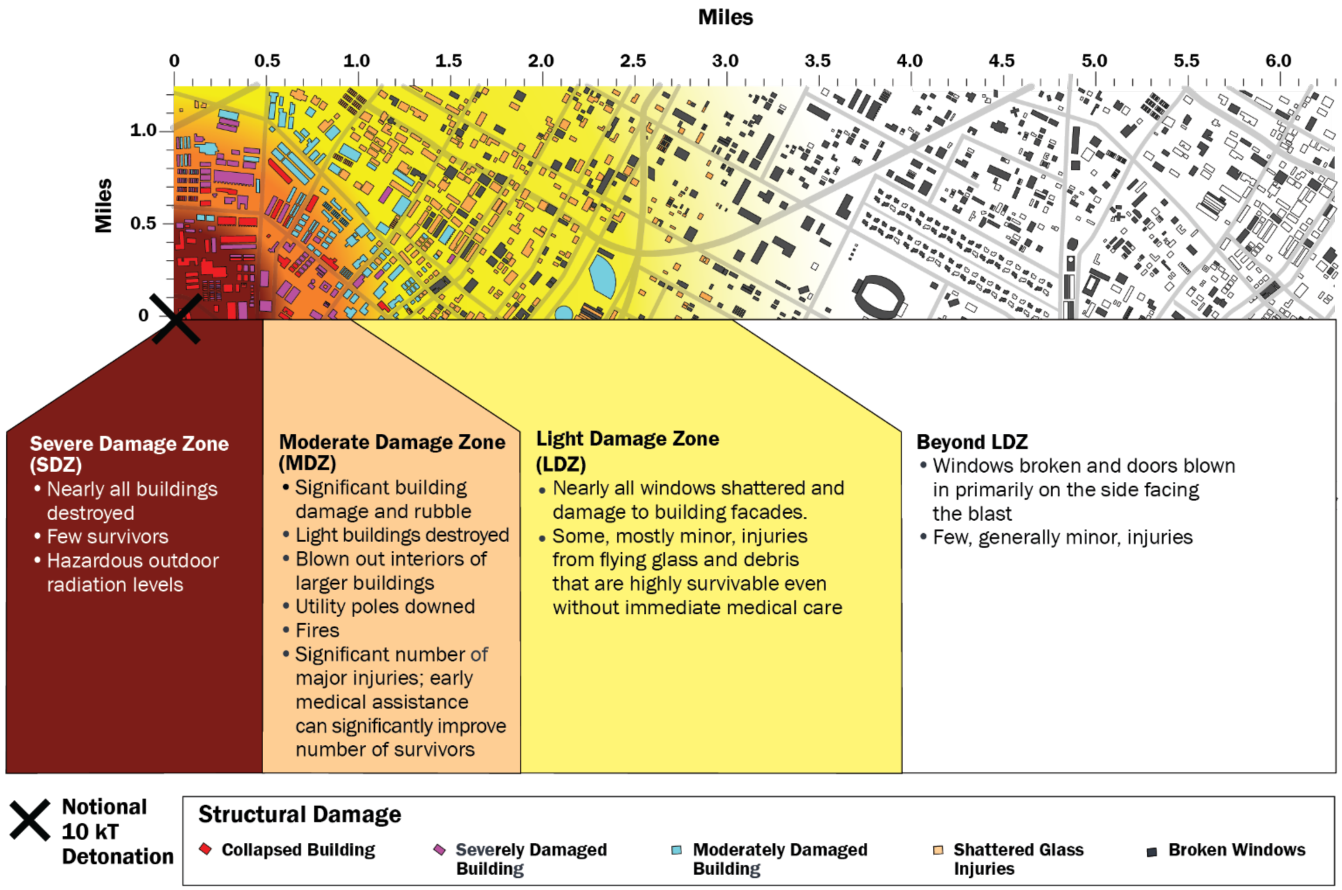

Figure 4: Blast Damage Zones, Including Observable Features[7]

In the Severe Damage Zone (SDZ), few buildings will be structurally sound or standing. Very few people are expected to survive in the SDZ. Rubble in streets will be impassable and there will probably be dangerous radiation levels outdoors, due to residual radiation from the detonation. As an example, the SDZ from a 10 kT surface detonation would extend out about 0.5 miles.

Within the SDZ, individuals inside large structures (e.g., subterranean parking garages or subway tunnels) at the time of the explosion may survive. Survivors should continue to shelter if safe to do so due to hazardous outdoor radiation levels for the first 24 hours.

In the Moderate Damage Zone (MDZ), building damage is substantial. The blast wave briefly creates winds greater than 100 mph, radiating outward from the detonation and then reversing direction to fill the vacuum left by the explosion. There will be significant structural damage within the MDZ, including blown out building interiors, blown down utility lines, overturned automobiles, caved roofs, some collapsed buildings, and fires. Telephone and streetlight poles may be blown over. In the MDZ,

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[7] Figure 4 assumes a nominal 10 kT surface detonation in a modern city. While distances would vary, the zone descriptions apply to any size nuclear explosion.

sturdier buildings (e.g., reinforced concrete) will remain standing, but lighter commercial and residential buildings may fall or become structurally unstable, and most wood frame houses will be destroyed. As an example, the MDZ would extend from about 0.5 mile to 1 mile from ground zero for a 10 kT nuclear explosion at ground level.

Blast damage may generate fires and expose fuel sources (gas line breaks, wood, etc.), potentially causing mass fires. Consequently, the MDZ should be an evacuation priority as soon as it is safe to do so (see Chapter 2 for more information).

In the Light Damage Zone (LDZ), most damage is caused by the powerful shockwave, like that of a thunderclap but with substantially more force. Most windows in the LDZ will break, many with enough force to cause injuries from flying glass and debris. Damage in this area will vary as shockwaves rebound off buildings, terrain, and the atmosphere. As an example, the LDZ would extend from about 1 to 3 miles from ground zero for a 10 kT nuclear explosion at ground level.

Beyond the LDZ, windows facing the blast may be broken for many miles, but there will be significantly fewer injuries.

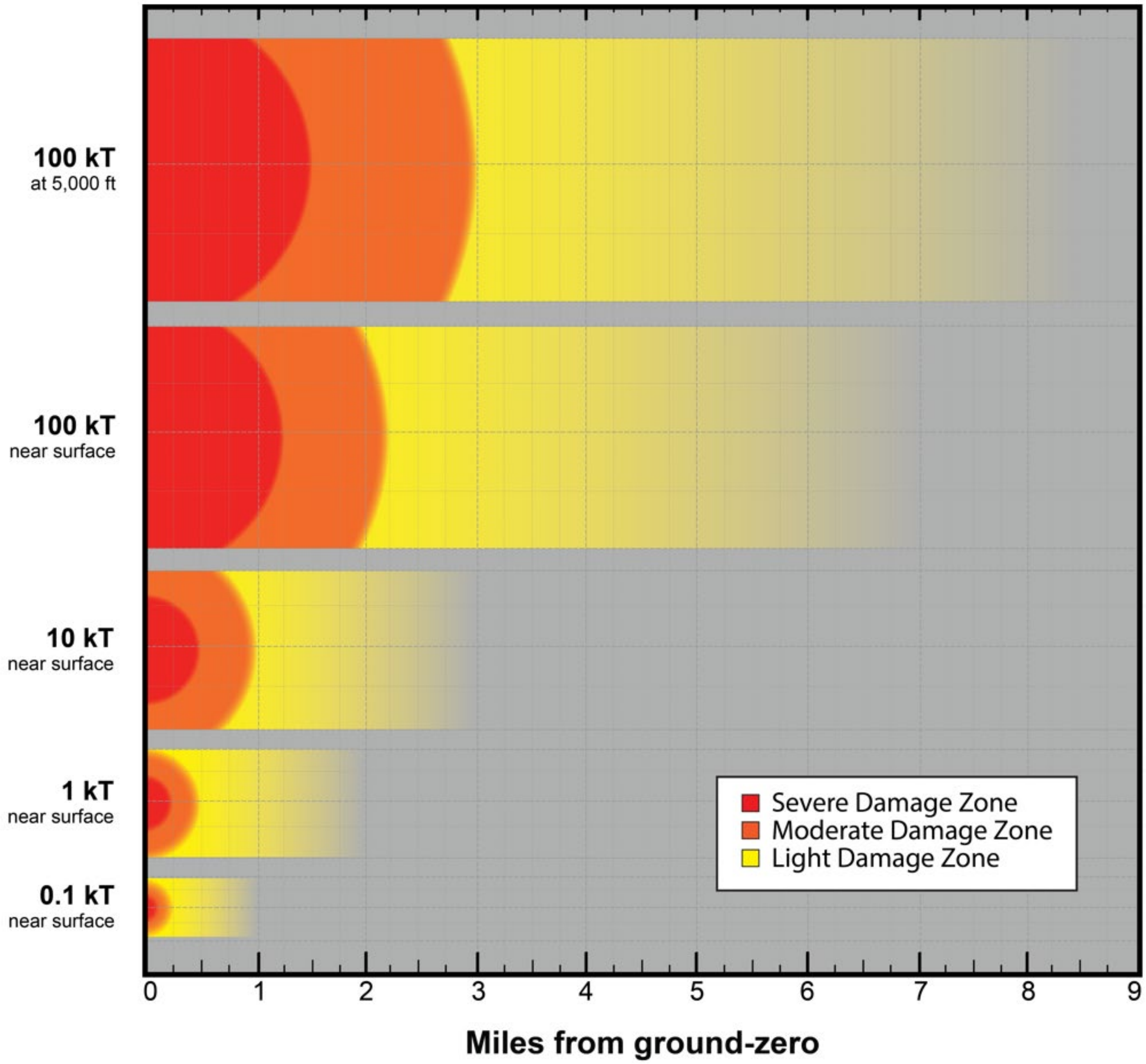

Figure 5: Theoretical damage zones shown side by side, comparing projected zones for 100 kT air detonations and for 100, 10, 1, and 0.1 kT near-surface detonations.[8] For every factor of ten yield increase, the effect ranges typically only increase by a factor of two. For example, the MDZ for 0.1, 1, 10, and 100 kT near-surface detonations extend out a ¼ mile, ½ mile, 1 mile, and 2 ¼ miles, respectively.

[8] In the case of 100 kT, near surface applies to both surface detonations and detonations 1,000 ft above ground.

1.1.2. BLAST INJURIES

In the urban environment, overpressure injuries, such as lung and eardrum damage, will likely be overshadowed by injuries incurred by collapsing structures and flying debris. In the SDZ and MDZ, many of these injuries will be fatal. Beyond the MDZ, flying debris injuries will be the most common.

In the MDZ, blast wave overpressures can produce flying debris and glass fragments with sufficient velocity to cause blunt trauma and deep lacerations. In the LDZ, windows may break with enough force to injure those standing directly behind them. Many windows will break even beyond the LDZ, but they are unlikely to produce injuries.

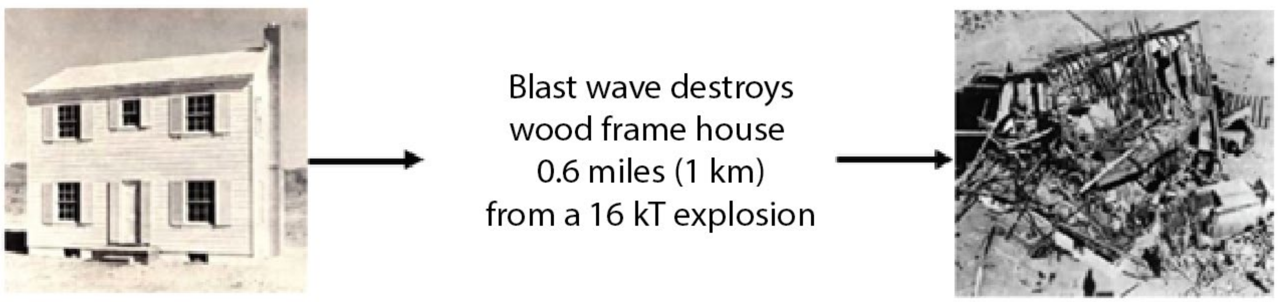

Figure 6: Blast wave effects on a house in the SDZ indicate low likelihood of survival in aboveground areas.[9]

If there is advance warning of a nuclear detonation, sheltering in the middle or basement of the nearest large building can prevent many blast, radiation, and thermal casualties.

For nuclear detonations without warning, many casualties can be avoided if individuals who see the intense and unexpected flash of light immediately seek cover. The flash can precede the blast wave by seconds, creating a short window for those in the blast zones to get away from windows and take cover.

There will be many significant injuries in the MDZ, requiring urgent medical care to save lives.

1.2. Prompt Thermal Effects and Fire

Unlike other explosive incidents, nuclear detonations generate an intense thermal pulse of energy (the nuclear flash). Thermal effects can extend beyond the MDZ for higher yield air burst detonations, resulting in flash blindness, burn injuries, and fires.

[9] This image is derived from Glasstone & Dolan, 1977, Figures 5.55 and 5.57.

1.2.1. NUCLEAR DETONATION–INDUCED FIRES

Nuclear detonation–induced fires in modern cities are not well understood and remain a major concern. The initial thermal pulse will start fires by igniting flammable materials. Subsequently, initial fires may induce secondary fires by igniting gas from broken gas lines and ruptured fuel tanks.

These initial and secondary fires may spread beyond the MDZ, depending on the weather and terrain. These fires may destroy infrastructure and threaten survivors and responders, including those actively sheltering or evacuating. If fires grow and coalesce, mass fires or uncontrollable firestorms may develop; however, modern U.S. city design and construction make firestorms unlikely.

> Nuclear detonation–induced fires represent a major hazard, especially in the MDZ, where rapid evacuation may be required. Smoke may be present, complicating the response and posing an additional hazard.

The SDZ is not conducive to fires because of the intense winds and flammable sources that are buried in deep rubble; however, leaking gas lines may still ignite. In residential areas comprised of wooden houses, significant fire activity may occur. The MDZ is more likely to sustain fires because many buildings will remain standing and infrastructure damage, such as broken windows, gas lines, and fuel tanks, will be extensive.

Depending on the material and its distance from ground zero, blast winds can extinguish or fan flames. Weather conditions (primarily wind and humidity levels) also influence fires, potentially causing them to spread quickly and over-run neighborhoods. Fires co-located with blast damage will affect access and response infrastructure, generating a fire hazard that is likely beyond anything that urban emergency management agencies have ever had to manage.

Coordination Opportunity

Planners should meet with their local and regional fire departments to discuss potential strategies for containing and mitigating fire spread in post-detonation conditions.

1.2.2. THERMAL INJURIES

Thermal radiation emitted by nuclear detonations causes burns in two ways—direct absorption of thermal energy through exposed surfaces or indirectly, from fires ignited by the detonation.

Flash Burns

Near the fireball, initial thermal energy is so intense that it will incinerate most objects. Lethal distance varies depending on yield, height of burst, line of sight with respect to the fireball, clothing, weather, terrain, buildings, and how quickly victims receive medical care. Thermal energy from the burst causes visible burn patterns on skin surfaces facing the fireball. Urban environments may provide substantial shadowing and reduce overall flash burn impact. However, people with a line of sight to the nuclear fireball may be subject to burn injuries up to a few miles away. The incidence and range of burns will increase with yield and, up to a point, with increasing height of burst. See Figure 25 in Chapter 4 for examples of flash burns.

Flame Burns

Fires will likely be prevalent in the MDZ, resulting in fatalities and injuries from flame burns and smoke inhalation. Treatment of thermal burns can be compounded by other injuries and radiation dose associated with a nuclear explosion.

1.3. Eye Injuries

In addition to eye injuries from flying glass and debris, observing the fireball at the moment of detonation can result in temporary or permanent eye injuries. Observing the flash of intense light can cause temporary flash blindness, even when observers are not looking directly at the detonation. Flash blindness may occur over 10 miles from a detonation in daylight, and even further at night. In the daylight, flash blindness can last several seconds, and at night, when pupils are fully dilated, flash blindness may last 5–10 minutes. Flash blindness may be followed by a darkened after image that lasts several minutes. Flash blindness will likely result in traffic accidents and blocked roads far from the damage zones and may cause aircraft accidents.

> The intense visible light that occurs is one of the hallmarks of a nuclear explosion and can often be seen from hundreds of miles away. Sudden exposure to such high-intensity sources of light can cause temporary blindness.
>
> Temporary flash blindness, or dazzle, can occur over 10 miles away (farther if the detonation occurs at night) and can result in blocked roadways due to car accidents.

Although much less common, retinal burns can occur if the intense fireball is in view at the instant of detonation. Retinal burns can result in permanent scarring, loss of visual acuity, and blind spots. This effect can occur several miles from the blast, and roughly double that range at night.

What Would You Do?

What type of guidance would you provide for flash-blinded/visually impaired individuals who need to evacuate?

1.4. Initial and Residual Radiation

1.4.1. INITIAL RADIATION

Radiation from nuclear explosions is categorized as either initial nuclear radiation, which occurs within the first minute, or residual radiation, which continues after the explosion. Initial nuclear radiation emanates directly from the detonating device and decreases rapidly with distance from ground zero; initial radiation casualties will likely be minimal beyond about a mile from ground zero.

Buildings and objects attenuate initial radiation, but even dense materials, like steel, do not absorb all the radiation near the detonation. Within a mile of the detonation, even those within or behind buildings may receive some initial radiation dose.

Acute radiation doses are large doses that occur over a short period of time (seconds to hours). These doses may cause short-term illness, including life-threatening effects. Some regions with significant blast and thermal damage may also have significant acute radiation doses. Survivors in these areas may suffer from radiation injury combined with blast and/or thermal injuries and should be triaged appropriately (see Chapter 4).

Refer To

The Effects of Nuclear Weapons: www.osti.gov/servlets/purl/6852629

Below, Figure 7 compares the area where unobstructed initial radiation may cause illness to those outdoors (1 Gy or 100 rad); as well as the area where thermal effects may cause second-degree burns. These areas are overlaid on damage zones for 0.1, 1, 10, and 100 kT surface detonations. Notice how initial radiation and thermal effects do not scale with blast effects. Initial radiation becomes a more dominant hazard for low yields, while the range of thermal effects becomes more prominent at higher yields.

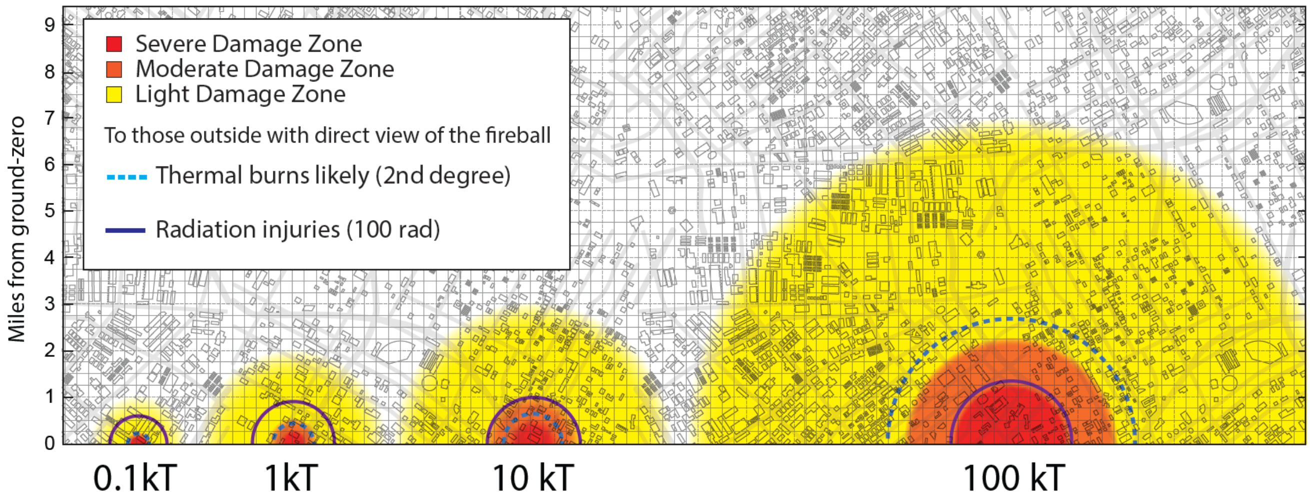

Figure 7: Radiation and burn injury ranges overlaid on damage zones demonstrating the extent of outdoor 1 Gy (100 rad) initial radiation and second-degree thermal burns for unobstructed 0.1, 1, 10, and 100 kT surface detonations.

Initial radiation–induced injuries can occur within a mile of a nuclear detonation.

Initial Radiation Variability

Figure 8 compares initial radiation exposure outdoors in an open field environment (on the right) to initial radiation exposure outdoors in a dense urban environment (on the left). This comparison highlights the stark contrast between open spaces and urban areas, where building shadowing and attenuation effects are considered. The attenuation effects shown are less dramatic in air burst scenarios, smaller cities, and lower-density cities.

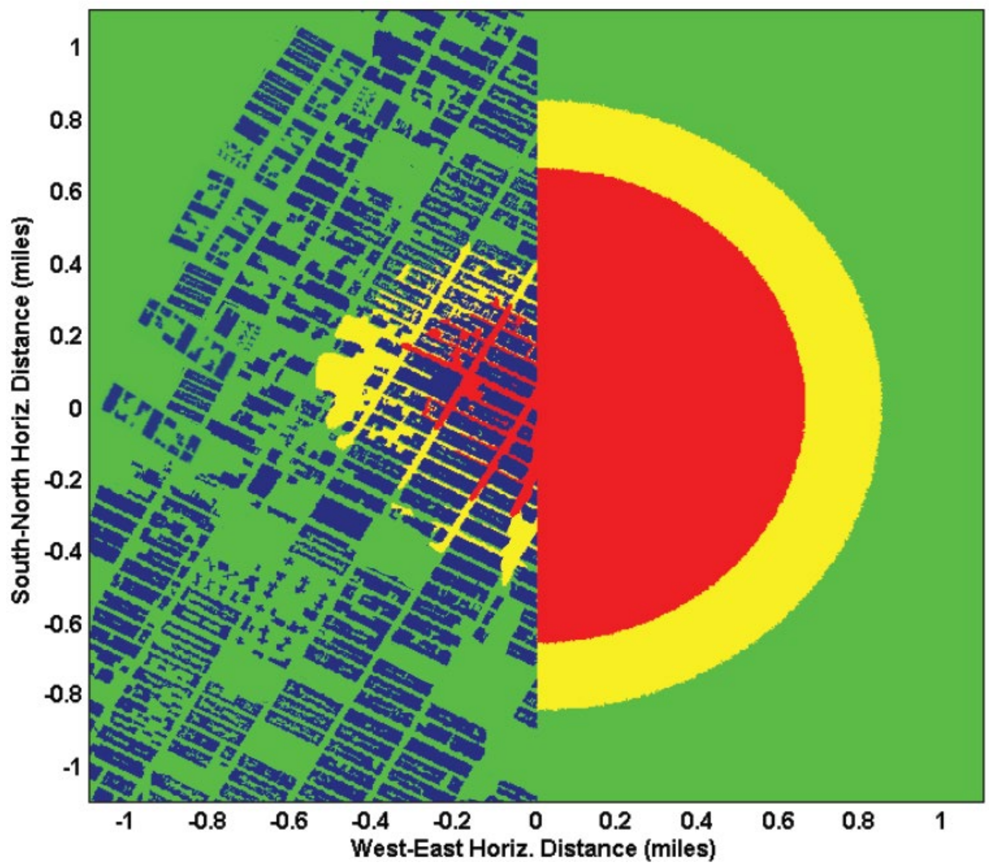

Figure 8: Outdoor initial radiation exposure levels for a dense urban area (left) and for a flat concrete slab (right) from a 10 kT surface-level detonation; red >8 Gy (>800 rad) (lethal), yellow 1–8 Gy (100–800 rad) (injurious to lethal); green < 1 Gy (<100 rad) (below an acute injury) (courtesy of Kramer, 2014).

1.4.2. RESIDUAL RADIATION

In addition to initial radiation during the detonation, the explosion also generates residual radiation that continues after the explosion. Residual radiation is emitted by two types of radioactive contamination: (1) activation products and (2) fission products.

Activation products are formed when initial radiation from the explosion interacts with surrounding materials (e.g., air, ground, and buildings), making them radioactive. Subsequently, these radioactive materials emit residual radiation as they decay.

Activation products can remain on the ground or be swept into the air, becoming part of the fallout cloud. Activation products continue to produce residual radiation depending on the materials present, weapon design, and height of burst. When detonations occur at sufficiently high altitudes, there is no substantial local fallout (though initial radiation can activate the ground, structures, and urban landscape near the detonation). An example activation area from a nuclear test can be seen in Figure 9.

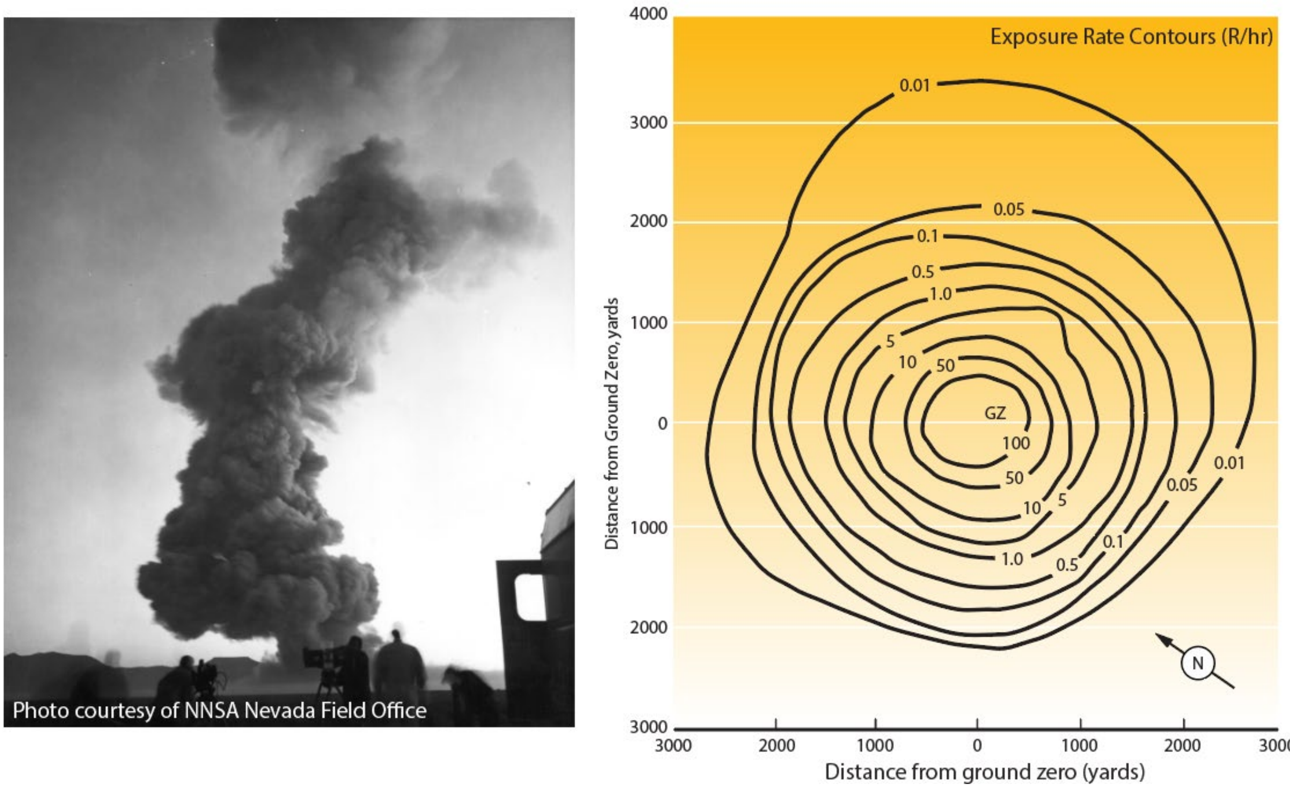

Figure 9: (Left panel) The 74 kT Plumbbob - Hood test was detonated at 1500' on July 5, 1957. (Right panel) Map of exposure rates (R/hr) one hour after detonation around ground zero (GZ).

Despite causing minimal fallout (due to the height of explosion), both Hiroshima and Nagasaki detonations produced a Dangerous Radiation Zone (DRZ)[10] at ground zero that lasted about 1 day, and then a Hot Zone (HZ)[11] at ground zero that lasted about five days (Imanaka et al., 2008).

Fission products are the radioactive material created when uranium or plutonium nuclei split apart and represent most of the radioactivity in fallout. In contrast to radiation released from a nuclear power plant (NPP) incident, most of the fission products released from a nuclear detonation are short-lived and more likely to produce local fallout, thereby making them most hazardous in the first few hours to days after the detonation.

Fission products are vaporized in the fireball and are retained within the resulting nuclear cloud. Due to the extreme heat of the fireball, the nuclear cloud rises rapidly, often several miles into the atmosphere. For near-surface detonations, the cratering and strong updraft below the cloud can

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[10] The Dangerous Radiation Zone is an area where radiation levels exceed 10 R/h and additional controls are warranted to reduce exposure. For more information, see the Dangerous Radiation Zone section.

[11] The Hot Zone is an area where radiation levels exceed 10 mR/h and additional controls are warranted to reduce exposure. For more information, see the Hot Zone section.

result in the incorporation of thousands of tons of dirt and debris (see Figure 11). The highly radioactive fission products condense on the dirt and debris pulled into the cloud, and the resulting particles (i.e., fallout) will be of varying sizes—some are so small they cannot be seen by the naked eye, while others can be as large as pebbles (see Figure 10).

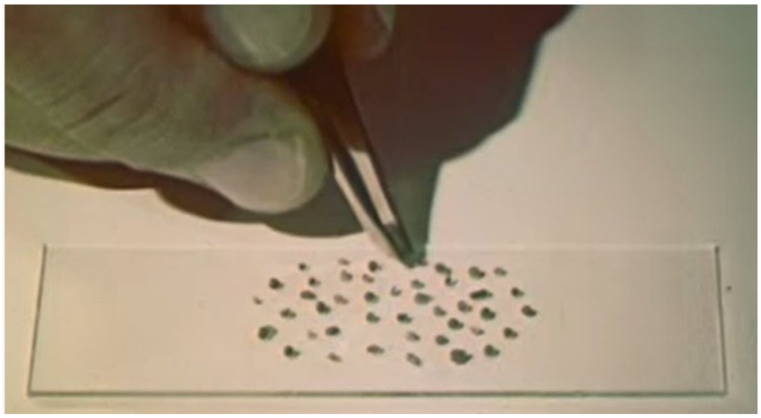

Figure 10: Fallout Particles from Near-Surface Nuclear Tests

After a nuclear detonation near the surface, immediately dangerous fallout will descend back to earth within the first few minutes to hours and can be readily visible as it comes down.

The larger particles tend to fall closer to the detonation site within the first couple of hours, whereas the small particles tend to stay in the atmosphere for much longer, perhaps for days or weeks following an event. Although details are highly dependent on weather conditions, the most dangerous concentrations of fallout particles deposit during the first few hours and are clearly visible as they fall, often being the size of fine sand or table salt.

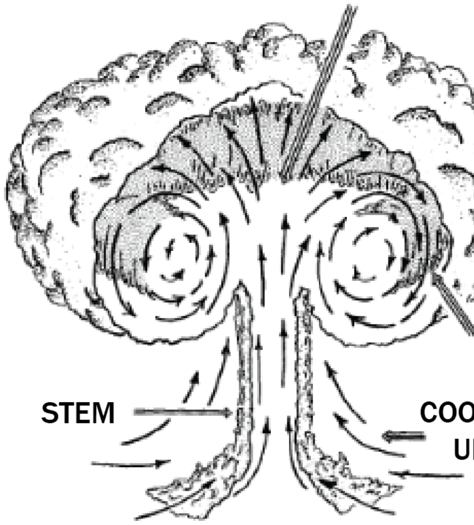

Figure 11: Example Mushroom-Shaped Cloud from a Near-Surface Nuclear Detonation (derived from Glasstone & Dolan, 1977)[12]

The direction of the fallout depends on the height of the cloud and atmospheric conditions. Since windspeed and direction vary at different altitudes, the nuclear cloud and descending fallout material may go in different directions than ground-level wind observations would predict.

Appropriate radiation monitoring is necessary to determine an area's safety. Besides dry deposition caused by gravity, radioactive particles in the nuclear cloud can also be brought to the ground by precipitation such as rain or snow, producing a local radiation hot spot[13] wherever it falls.

Action Item

Ensure your EOC has access to rapid fallout modeling software tools and services that provide fallout hazard area estimations, such as IMAAC. Modeling resources can be found on gis.fema.gov/Model-and-Data-Inventory.

[12] Toroidal refers to the donut-like shape in mushroom cap of the cloud. The donut shape is called a torus.

[13] A radiation hot spot is a region in which the radiation levels are significantly higher than in neighboring regions (US Nuclear Regulatory Commission, 2021).

Coordination Opportunity

Coordinate with federal peers to access federal modeling capabilities, which track incidents, estimate direction and scale of fallout, and map predicted impact areas.

1.5. Height of Burst (HOB) Considerations

The height of the nuclear explosion, relative to ground level, is referred to as the HOB. The HOB impacts many aspects of nuclear weapon effects, including the fraction of energy released as thermal energy; fallout hazard magnitude; blast wave strength and interaction with the ground; and the EMP severity and range.

1.5.1. NEAR-SURFACE BURST

A surface burst is a nuclear explosion at or near the surface that incorporates ground material into the resulting nuclear cloud. The mass from ground material reduces thermal output and the range of thermal effects, compared to a low-altitude air burst with the same yield. The ground or nearby material incorporated into the resulting cloud combines with the fission products to form fallout particles that "fall out" of the cloud within minutes to hours after detonation. Local fallout radiation levels from a surface burst will probably be high. In a surface burst scenario, the dominant hazards are blast, local fallout, and initial radiation.

1.5.2. LOW-ALTITUDE AIR BURST

A low-altitude air burst is a nuclear explosion at a high enough altitude that the fireball does not interact with the ground, so dirt and debris are not incorporated into the cap of the nuclear cloud. Low-altitude[14] air burst detonations generate larger thermal and blast damage areas than near-surface bursts, but local fallout will be minimal or negligible. The lack of ground material in the nuclear cloud causes fission products to form microscopic particles that remain in the atmosphere for days to months afterwards. Precipitation can cause "rainout" downwind, producing localized, low dose rate radiation hot spots. In a low-altitude air burst scenario, the dominant hazards are blast, thermal (for higher yields), and initial radiation (for lower yields).

Figure 12 illustrates nuclear mushroom cloud characteristics for various aboveground HOBs (shown by red stars). These clouds can be organized by regimes[15] based on relative HOB. The "negligible local fallout" regime in Figure 12 represents air bursts with white mushroom caps, where minimal material from the ground is incorporated into the cloud, so less local fallout is expected. For

[14] For yields considered in this document, low-altitude detonations are generally defined as above near-surface detonations and less than 16,400 ft (5 km) above the surface.

[15] The regimes referenced throughout were derived from Spriggs et al., 2020.

detonations nearer to the ground, represented by the “hazardous fallout” regime in Figure 12, the cloud cap is darkened by ground material and hazardous levels of local fallout should be expected. In altitude air bursts, shown by the clouds in the “some local fallout” regime in Figure 12, partial mixing of ground material with fission products will generate some local fallout, though this will be less severe than that of detonations nearer the surface. Visual observations of the cloud and the color of the cloud cap can help in determining if the detonation is near the surface (darker cloud cap) with more hazardous fallout or an air burst (cloud cap white or light color compared to the stem of the mushroom cloud) that may indicate less hazardous fallout conditions. Regardless, it is critical to rely on multiple information sources, especially radiation survey measurements, to determine radiation hazards in an area.

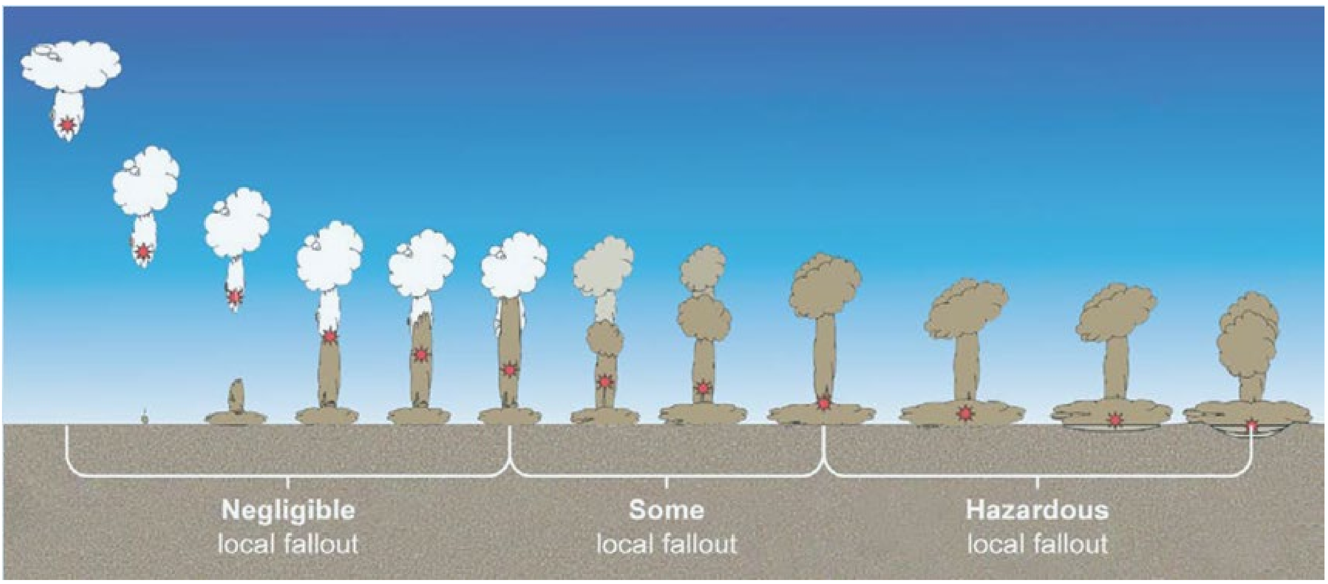

Figure 12: Examples of cloud shapes and shading for various heights of burst. Color of cloud indicates the amount of environmental materials, like dirt, in the cloud; brown clouds have the most materials and white clouds have the least (derived from Spriggs et al., 2020).

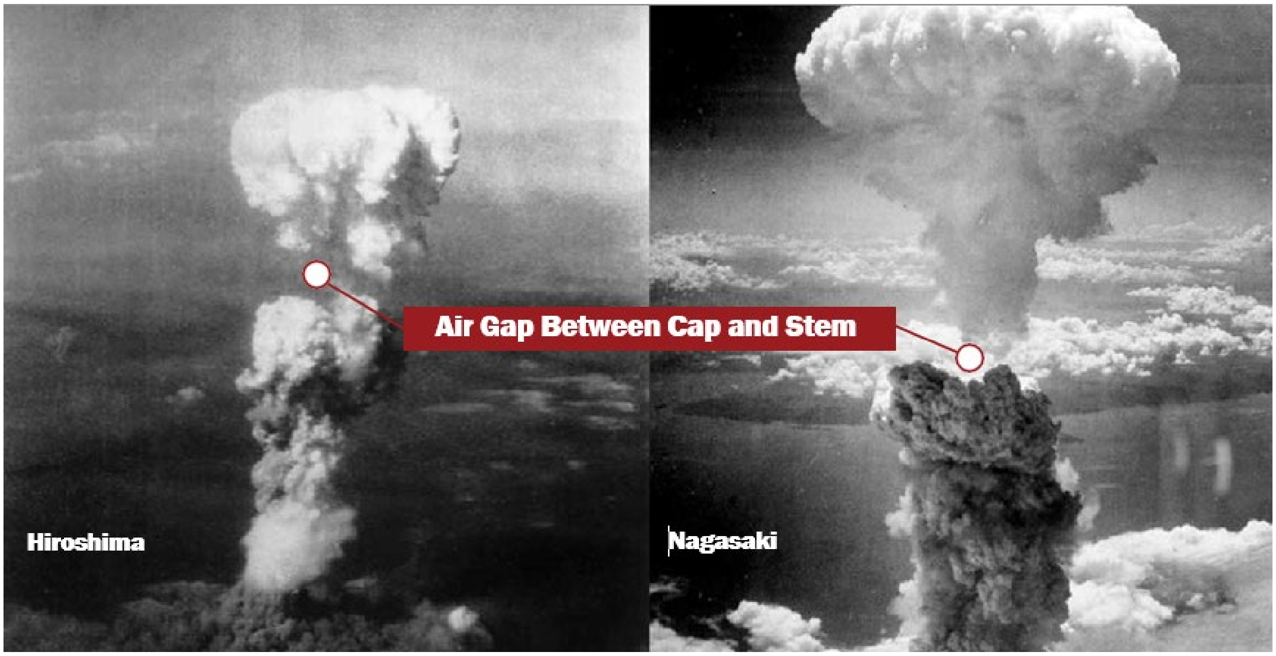

Figure 13: Air Gap Between the White Mushroom Cap Containing Fission Products and the Dark Stem of Dirt and Debris for Hiroshima and Nagasaki

In the **negligible fallout regime** (Figure 12), the fallout radiation may be less hazardous, but the initial radiation exposure during the explosion may still harm people. The Hiroshima and Nagasaki detonations are examples of air bursts without significant local fallout, although some victims still suffered radiation sickness from the initial pulse of radiation. The mushroom cloud images from Hiroshima and Nagasaki show an airgap between the cap of the cloud and the stem (see Figure 13). Most of the highly radioactive fission products are fine particles contained within the white cloud cap, which did not mix with the dirt and debris from the ground. The small radioactive particles remained aloft, resulting in minimal local fallout and allowing more diffusion and decay before depositing on the ground.

What Would You Do?

How would your response actions, based on your plans, change if you knew the cloud cap was dark brown? What if the top of the cloud was white?

Near-surface detonations (hazardous local fallout regime) will generate local fallout that lands on surfaces and creates a radiation field. Local fallout is primarily due to large particles that fall relatively quickly and land on the ground in the first 24 hours. These large particles are too large to drift far with the wind, be resuspended from the ground back into the air, or pose a respirable hazard. Rather, these particles are hazardous because they emit external gamma radiation that can travel hundreds of feet through the air. As such, individuals who are unprotected (e.g., outside) after fallout has deposited may be exposed to radiation.

Because many fission products are short-lived, radiation levels decrease rapidly with time. Fallout gives off over half of its energy in the first hour and then continues to decay rapidly, as shown in Figure 14. Sheltering during the first few hours (up to 24 hours) is a critical protective measure (for more information on sheltering, see Chapter 3).

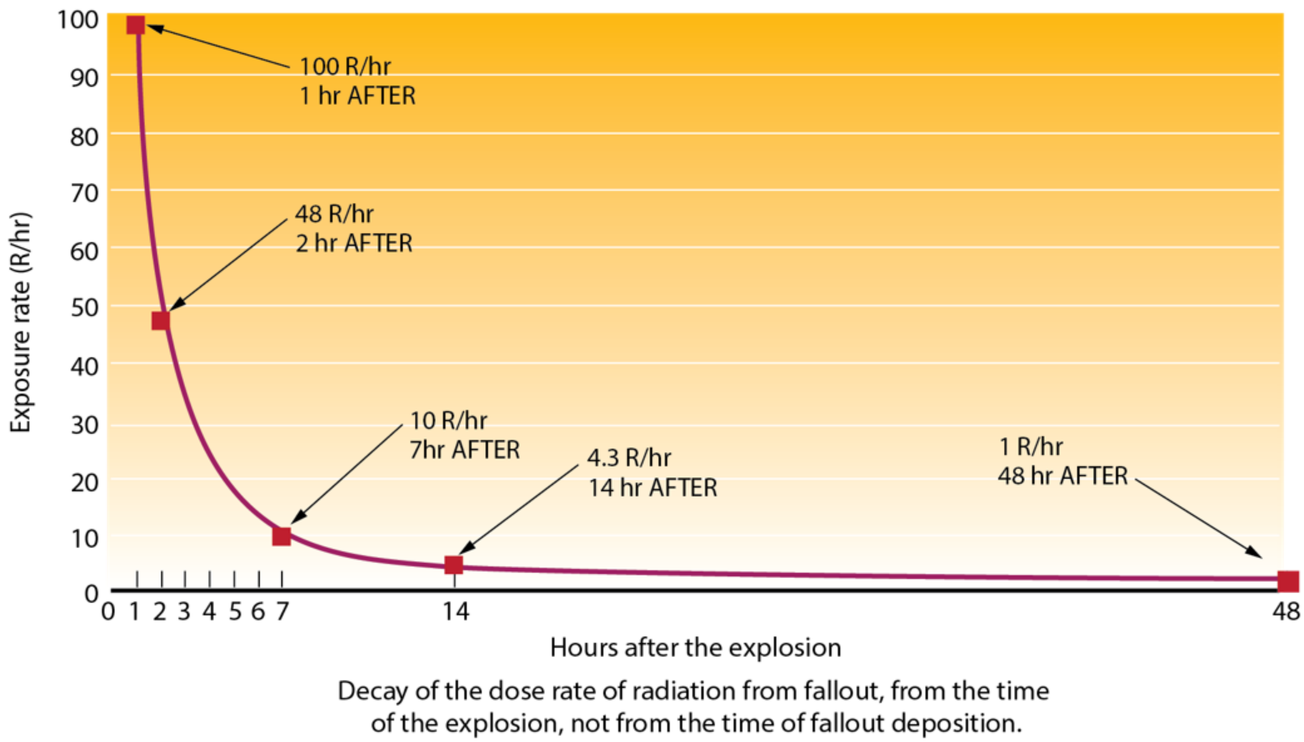

Figure 14: The decay of fallout radiation from the time of detonation. Decay of the fallout product dose rate, from the time of the explosion (not from the time of fallout deposition). The nominal 100 R/hr starting value in this example is arbitrary.

Although fallout patterns depend on weather conditions, the most dangerous fallout particle concentrations often occur within tens of miles downwind of ground zero and typically fall within the first few hours. Wind direction and speed change with altitude, which can cause the fallout to be deposited in more than one direction.

Fallout particles near the detonation are relatively large and may be easily visible, both as a cloud of debris and as they fall to the ground. Because of their size, the inhalation hazard is small compared to the external dose received from particles on the ground.

1.6. Radiation Zones

For response planning, this guidance describes two fallout hazard/residual radiation zones: the DRZ and HZ. Unlike the blast damage zones, the DRZ and HZ are not visually distinguishable and must be determined by radiation level measurements.

1.6.1. DANGEROUS RADIATION ZONE (DRZ)

The DRZ is characterized by:

- Radiation levels of 10 R/hr and above.
- Potential for acute radiation injury.
- Potentially located tens of miles downwind.
- Begins to shrink within a few hours due to radioactive decay.

The DRZ was called the Dangerous Fallout Zone (DFZ) in the previous version of this guidance. This change harmonizes this guidance with other national standards and all other federal guidance for response to radiological or nuclear emergencies.

A 10 R/hr radiation exposure rate defines the outside perimeter of the DRZ, with higher exposure rates occurring inside the DRZ. For a near-surface detonation, the SDZ will have DRZ radiation levels within it and the DRZ will overlap with the downwind sides of MDZ and LDZ for near-surface detonations.

The DRZ is very hazardous, so response operations within it must be justified, planned, and optimized to minimize radiation exposure. Responders should refrain from undertaking missions in potentially dangerous areas until radiation levels are known and responder exposures monitored. Responder planning recommendations for the DRZ are provided in DRZ section of Chapter 2.

Everyone inside the DRZ should seek immediate shelter. Even beyond the DRZ, sheltering may be warranted to minimize acute radiation exposure to the population and minimize cancer risk. Until the magnitude and direction of fallout are established, those not involved in response activities within 50 miles of a nuclear detonation should seek adequate shelter. See Chapter 3 for additional discussion on finding the best shelter.

Response operations in the DRZ should be minimized to protect responders. Monitoring radiation levels is imperative for the response community to identify and address hot spots. Predictive fallout models can be helpful, but measured radiation levels (including aerial measurement surveys) are necessary when determining response options and developing protective action decisions.

Due to radioactive decay, the DRZ boundary changes rapidly in the first few days. It reaches its maximum extent after the first few hours and then shrinks in size, perhaps going from tens of miles to a mile or two in just one day (see Chapter 2 for more information).

Action Item

Ensure methods for obtaining and interpreting radiationreadings and models are incorporated in response plans. Consider strategies for collecting, communicating, and mapping radiation readings.

1.6.2. HOT ZONE (HZ)

HZ is characterized by:

- 0.01 R/hr (10 mR/hr) to 10 R/hr radiation levels.
- Operating in the HZ is unlikely to result in acute radiation effects, but radiation dose should be minimized.
- Can extend in various directions for hundreds of miles.
- Decay of radioactive material causes this zone to begin shrinking within 24 hours.

The residual radiation in the HZ produces radiation exposure rates from 0.01 to 10 R/h. These levels are not immediately dangerous to life or health. However, protective actions (e.g., sheltering and/or evacuation, food restrictions, and water advisories) may be warranted within the HZ to prevent longer term health effects. The HZ can extend hundreds of miles downwind, depending on yield, height of burst, and weather, before shrinking in size due to radioactive decay.

Emergency activities can be performed in the HZ without exceeding EPA dose guidelines for emergency response operations, provided appropriate dose monitoring is performed. Staging, triage, and community reception centers (CRCs) should be established outside of the HZ whenever possible (for more information, see Chapter 2).

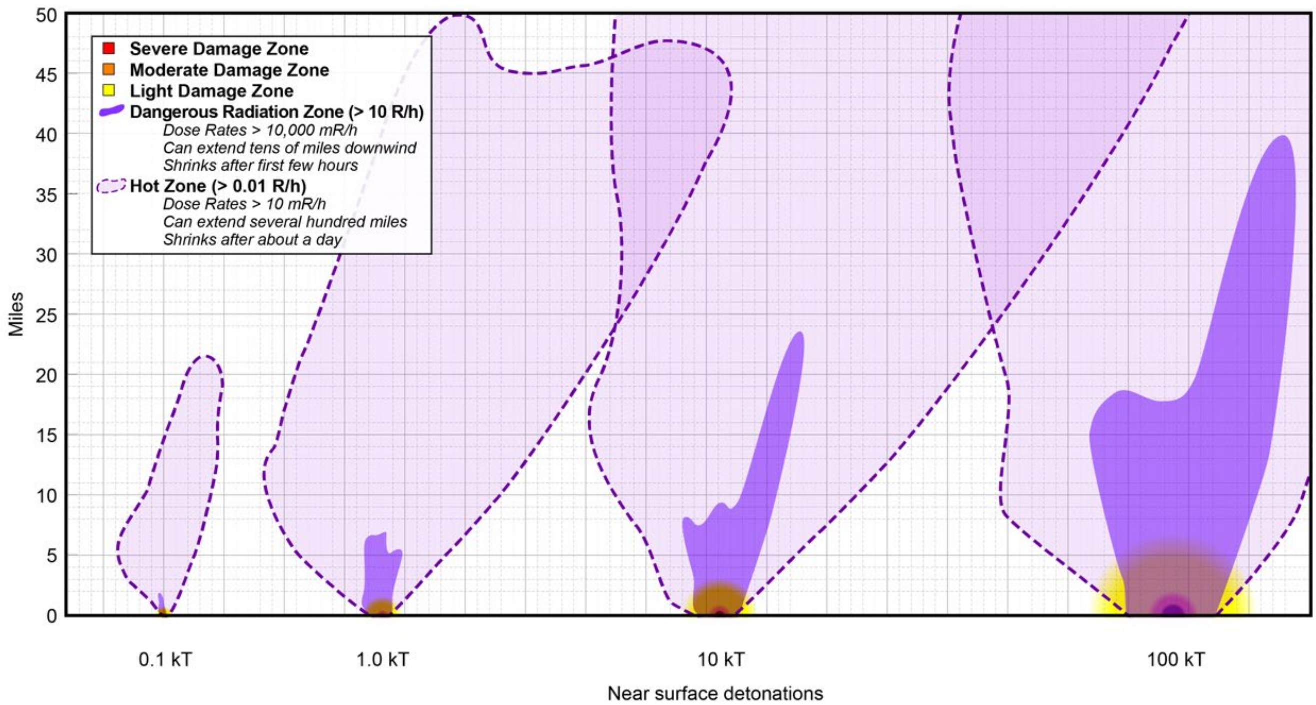

Figure 15: Illustrations of Response Zones for a Variety of Yields

The HZ, like the DRZ, should be established by measured radiation levels. The HZ is bound by 0.01 R/h and higher exposure rates within the 10 R/h boundary. The SDZ is expected to have HZ radiation levels or higher, even for low air bursts. The HZ will overlap with parts of the MDZ and LDZ for near-surface detonations. Figure 15 illustrates the relationship between the HZ, damage zones, and the DRZ for surface detonations of various yields.

1.6.3. LONG-RANGE FALLOUT IMPACTS

Near-surface detonations can generate elevated but low radiation levels that are easily detected by common responder radiation detection instruments very far from ground zero. Although low-level radiation outside of the HZ is not an immediate health concern, it may generate public concern. These elevated radiation areas are not a planning guidance zone because no immediate action is required. However, local authorities may suggest protective actions out of an abundance of caution and long-term population monitoring may be warranted (see Chapter 5).

Figure 16, based on data from the National Cancer Institute (NCI), shows the assessed dose rate from fallout deposition from the 1953 Upshot-Knothole Simon test in Nevada (a 43 kT detonation on a 300-foot tower). Even 36 hours after detonation, areas shown in red would have been above 1 mR/hr. West of the Mississippi River, this was largely due to dry deposition of fallout particles. East of the Mississippi River, the deposition was largely due to rainout of particles from the air onto the ground. The hot spot in the northeast U.S. was caused by heavy rainfall that occurred 36 hours after the detonation.

If instead of dry deposition in Arizona, New Mexico, and Texas, there had been an equivalent heavy rain within 18 hours of the nuclear detonation, those states might have experienced hot spots that exceeded 1 R/h and local authorities would have had to consider protective actions to prevent exposures. Planners should be aware that precipitation may cause local radiation hot spots that require public protective actions even a hundred miles or more downwind from ground zero. The locations of these hot spots are difficult to predict and all jurisdictions that may be at risk should closely monitor local conditions following an event.

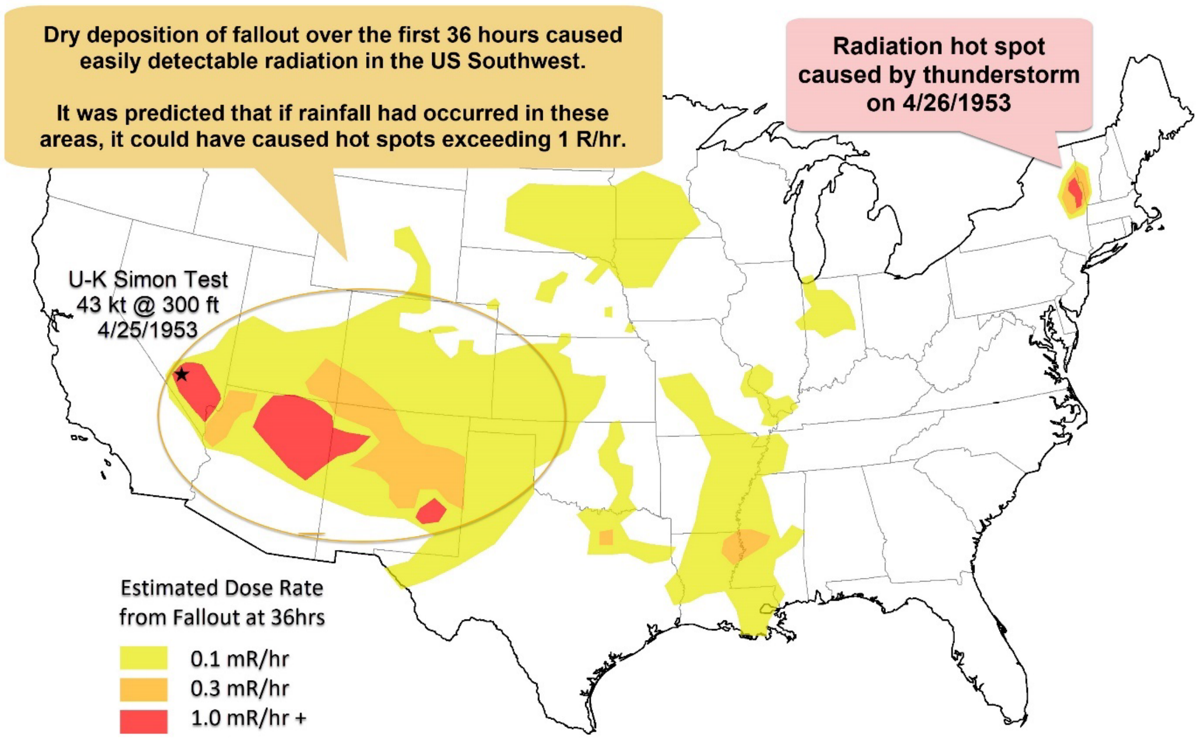

Figure 16: Estimated gamma dose rate above background levels, if measured 1 m above ground at H+36 hours following one particular U.S. historical nuclear test (Upshot-Knothole Simon on 4/25/1953; 43 kT detonation on a 300-foot tower). Median dose rate estimated by county, from measured fallout activity interpolated across counties (derived from NCI, 1997).

Residual radiation on the ground will vary significantly from one case to another, even for the same nuclear yield and HOB, due to differences in terrain/land use (e.g., rural versus urban), device design, and meteorological conditions (e.g., wind and precipitation). Widespread and ongoing radiological measurements are essential to confirm HZ/DRZ extents and improve emergency response modeling predictions. (See Appendix 1.2: Residual Radiation Variability for further discussion.)

Fallout from air bursts can produce separate, discontinuous HZs or DRZs. For air burst scenarios, the DRZs near ground zero may be small or non-existent (compared to ground burst scenarios of the same yield). An air burst will also have a much smaller HZ, becoming smaller as height of burst increases. However, precipitation events can produce downwind HZ hot spots, potentially far from ground zero.

Because air burst fallout remains aloft longer and travels farther, detectable radiological deposition may occur at larger downwind distances. Air burst hot spots can reach regional/continental scales due to both dry settling and wet rainout that deposit radioactive particles on the ground. This may result in widespread demand for radiological emergency response resources, including radiation surveying and population monitoring capabilities.

Fallout models of residual radiation dose rates may be averaged over areas of a square mile or more. Consequently, models do not predict localized exposure rate variations and responders may encounter localized, non-uniform residual radiation hot spots early in the response that can only be identified with real-time measurements.

1.6.4. ZONE SUMMARY

This guidance is characterized by several important planning zones. Appropriate actions for each zone are discussed in Chapter 2.

- **Severe Damage Zone (SDZ):** destroyed infrastructure and high radiation levels
- **Moderate Damage Zone (MDZ):** significant building damage, rubble, downed utility lines and some downed poles, overturned automobiles, fires, and serious injuries
- **Light Damage Zone (LDZ):** broken windows and easily managed injuries
- **Dangerous Radiation Zone (DRZ):** prolonged outdoor exposure can result in injury or death
- **Hot Zone (HZ):** actions warranted to reduce radiation exposure and the possibility of long-term health effects

1.7. Radiation Injuries and Fallout Health Impacts

In fallout areas, external radiationexposure can be a significant health concern. High radiation doses can cause acute health effects (manifesting in a short time), including death. One of the long-term (years) radiation effects can be an increased risk of cancer. Minimizing exposure to radiation is a valuable policy and response goal for both responders and the public. Generally, a radiation dose received over a long period of time is less likely to result in health effects than if the same dose were received over a short period of time.

Minimizing dose levels is a priority in the DRZ, due to potentially acute effects and lethal doses. Further downwind, in the HZ, adequate shelter is critical to reduce unnecessary radiation exposures. Chapters 2 and 3 provide more information on radiation dose management and protective actions. Chapter 4 provides more information on the effects of various radiation exposures.

> If warning is provided just prior to a nuclear detonation, the most effective lifesaving opportunity will be to get inside a robust shelter to protect against initial blast effects. Fallout exposure can be effectively minimized by taking shelter in a sufficiently protective structure immediately

following a nuclear detonation and remaining safely sheltered from the fallout for at least 24 hours.

People caught in an area while fallout is depositing should find suitable shelter and perform dry decontamination to brush off any fallout particles. This rudimentary decontamination protocol may be necessary for those leaving fallout areas or entering shelters. Effective external decontamination is straightforward—remove/change the outer layer of clothing and footwear and brush/wipe exposed skin. If contamination is not brushed or washed off, particles in contact with the skin can cause localized beta burns.[16] For decontamination information, see Chapter 5.

1.7.1. RADIATION DOSE FROM FALLOUT

Dose caused by external exposure occurs when the radiation source is outside the body. This includes initial radiation, ground contamination, and contamination on the clothing or skin. Removing the person from the radioactive environment, or removing the contamination from the clothing or skin, stops the exposure.

Dose caused by inhalation or ingestion of fallout is not a primary concern during initial phases of the response. Historical data demonstrates that dose from these sources is less than 10% of total dose received while being outside in fallout areas where the primary hazard is external exposure (Crocker et al., 1966; Edwards et al., 1985; Levanon & Pernick, 1988).

Fallout exposure can be effectively minimized by taking shelter in a protective structure. The outdoor radiation hazard from fallout (often referred to as the "ground shine dose") is typically orders of magnitude more hazardous than internal exposure concerns resulting from inhalation or ingestion of radioactive material. Even buildings with broken windows can provide adequate protection from ground shine dose. For more information on sheltering, see Chapter 3.

1.7.2. COMBINED INJURIES

When a radiation injury from radiation exposure occurs in conjunction with trauma and/or burns, it is called "combined injury." Combined injury carries a worse prognosis than either injury occurring alone. Therefore, patients with combined injury will be triaged differently than patients with only one type of injury. See Chapter 4 for more information about medical concerns.

[16] Beta burns are severe sunburn-like injuries caused by beta radiation from particles deposited on the skin.

1.8. Electromagnetic Pulse (EMP) Effects

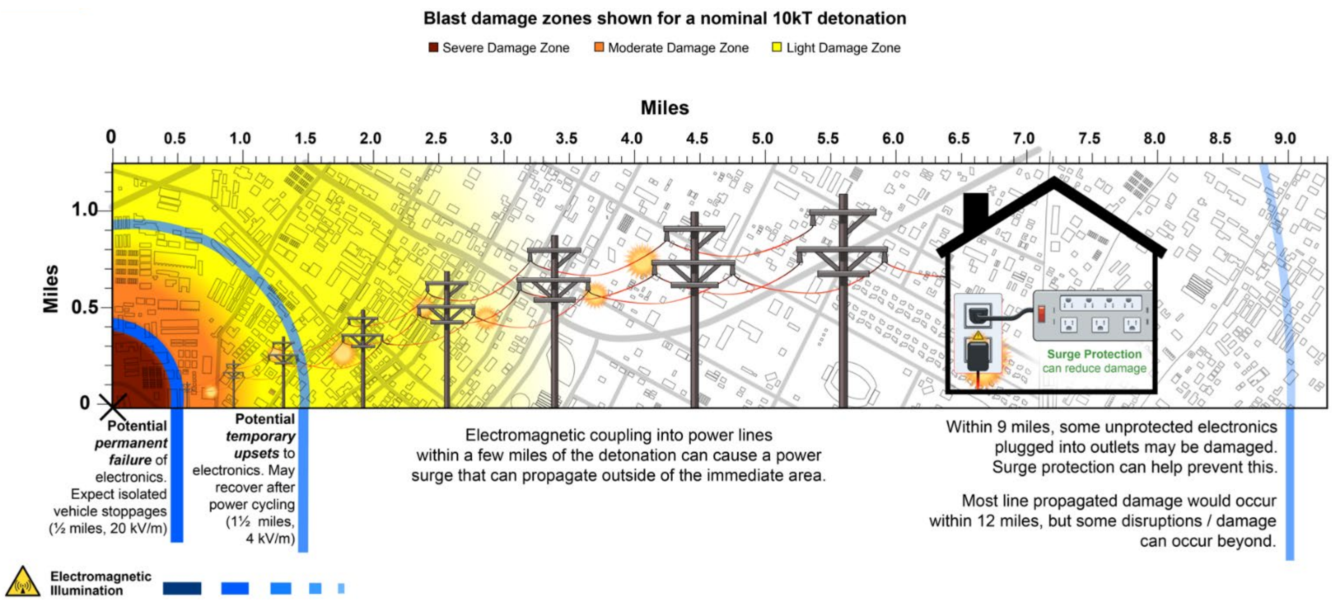

Figure 17: Source Region EMP (SREMP) Illumination Range and Power Grid Coupling Disruptions

EMP from a low-altitude[17] detonation differs from high-altitude[18] EMP (HEMP) (these differences are described in Appendix 1.1). EMP from a low-altitude detonation is generally limited to a Source Region EMP (SREMP).

There are two major disruptive effects of a SREMP (shown in Figure 17 above):

- Electromagnetic (EM) Illumination: SREMP impact electronic equipment through induced voltage on internal wires and conductors. These induced voltages may disable or damage equipment.
- Line Coupling: Large voltage/current surges in long power lines and other conductors that pass near the detonation. This can propagate for significant distances, resulting in disruption and potential damage a few miles outside the blast damage area.

Key points on SREMP associated with the planning guidance scenarios:

- EMP effects are not strongly dependent on yield or HOB below 3 miles (5 km).
- Temporary (hours to days) power outages may extend tens of miles beyond the blast damage area, depending on power grid configuration and detonation location.

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[17] For the purpose of EMP effects, anything less than ~16,400 ft above ground level (AGL) is considered low altitude.

[18] Greater than 30 km AGL.

- Power system transformer damage from EMP effects, which is difficult to repair quickly, is generally limited to a few miles from ground zero.
- EM illumination on power lines within a few miles of detonation can cause power surges outside the MDZ that can damage unprotected equipment plugged into wall sockets up to 9 miles away.
- Easily repairable damage to power system substation components (tripped breakers, damaged relays, etc.) can occur several miles from the detonation along long, running non-branching power lines.

For an in-depth discussion of EMP effects, see Appendix 1.1: Electromagnetic Pulse (EMP), High-Altitude EMP (HEMP), and Geomagnetic Disturbance (GMD).

Refer To

Source Region Electromagnetic Pulse Planning Considerations (2021): doi.org/10.2172/1813668

2. A Zoned Approach

This chapter examines the five key response zones introduced in Chapter 1 and identifies their corresponding hazards, response priorities, public protection priorities, and emergency worker protective measures. Hazards and radiation zones change over time and depend on specific detonation characteristics, especially the yield and HOB.

Effective nuclear detonation response requires all available resources. Due to geographically expansive impacts, responders and emergency management organizations will be present in many of the zones discussed below. In addition to ensuring their own safety, response organizations must prioritize both lifesaving activities and developing situational awareness to facilitate a coordinated and rapid response.

Since planning guidance cannot anticipate all problems and solutions in advance, this document establishes an adaptable, zoned approach to prioritize response activities and coordinate collective allocation of scarce resources among jurisdictions, states, and regional organizations. This approach provides flexibility to responders who must process an overwhelming amount of incident information and rapidly generate prioritized response actions.

To support response, neighboring jurisdictions must develop a COP. Response priorities and public protective measures differ for large firesand fallout, so determining the extent of both hazards is an important initial priority.

Although the bulk of federal support will not be available in the first 72 hours post detonation, some remote assistance (such as modeling and public messaging) will be available almost immediately. FSLTT jurisdictions must prepare to receive and integrate national response resources. Federal assistance includes specialized nuclear/radiological capabilities described in the Nuclear/Radiological Incident Annex (NRIA) to the Response and Recovery Federal Interagency Operational Plans (FIOPs). To access specialized nuclear/radiological planning and response tools, contact FEMA's CBRN Office.

Coordination Opportunity

Response to a nuclear detonation may largely be provided by neighboring jurisdictions, so advance planning is required to ensure mutual aid agreements and response protocols can address the unique challenges associated with a nuclear detonation.

Action Item

Emergency responders and planners must understand how to obtain and use IMAAC products.

Refer To

NRIA to FIOPs: www.fema.gov/sites/default/files/2020-07/fema_incident-annex_nuclear-radiological.pdf.

Although previous nuclear detonations have informed our understanding of nuclear effects, there is uncertainty about what would occur if a nuclear device exploded in a modern U.S. city. Modeling may estimate the extent and magnitude of affected areas based on simplified assumptions, but the zones will ultimately be identified through physical observations and real-time radiation readings from emergency workers in the area.

A zoned approach tailors response to the hazards present in different areas surrounding the detonation. However, regardless of zone, the best initial protective action the public can take is to "Get Inside, Stay Inside, Stay Tuned." This guidance is applicable to scenarios with limited (tens of minutes) warning as well as no-notice incidents. As with all guidance, immediate threats to life take priority, so evacuation may be warranted in the event of fire, building collapse, or medical emergencies.

"Get Inside, Stay Inside, Stay Tuned" is the most important protective action, because it mitigates fallout exposures.

- **Get Inside** a basement or the middle of a large, dense building.[19] It is best to be in a shelter when fallout arrives. Any shelter is better than being outside for extended periods of time.
- **Stay Inside** for 12–24 hours, unless provided additional guidance.
- **Stay Tuned** for instructions and updates. AM/FM radio is best, but television, cellphone, or internet options are viable, if available. For more information on emergency messaging, see Chapter 7.

[19] For more information about adequate shelters and a discussion of dense buildings, see Chapter 3.

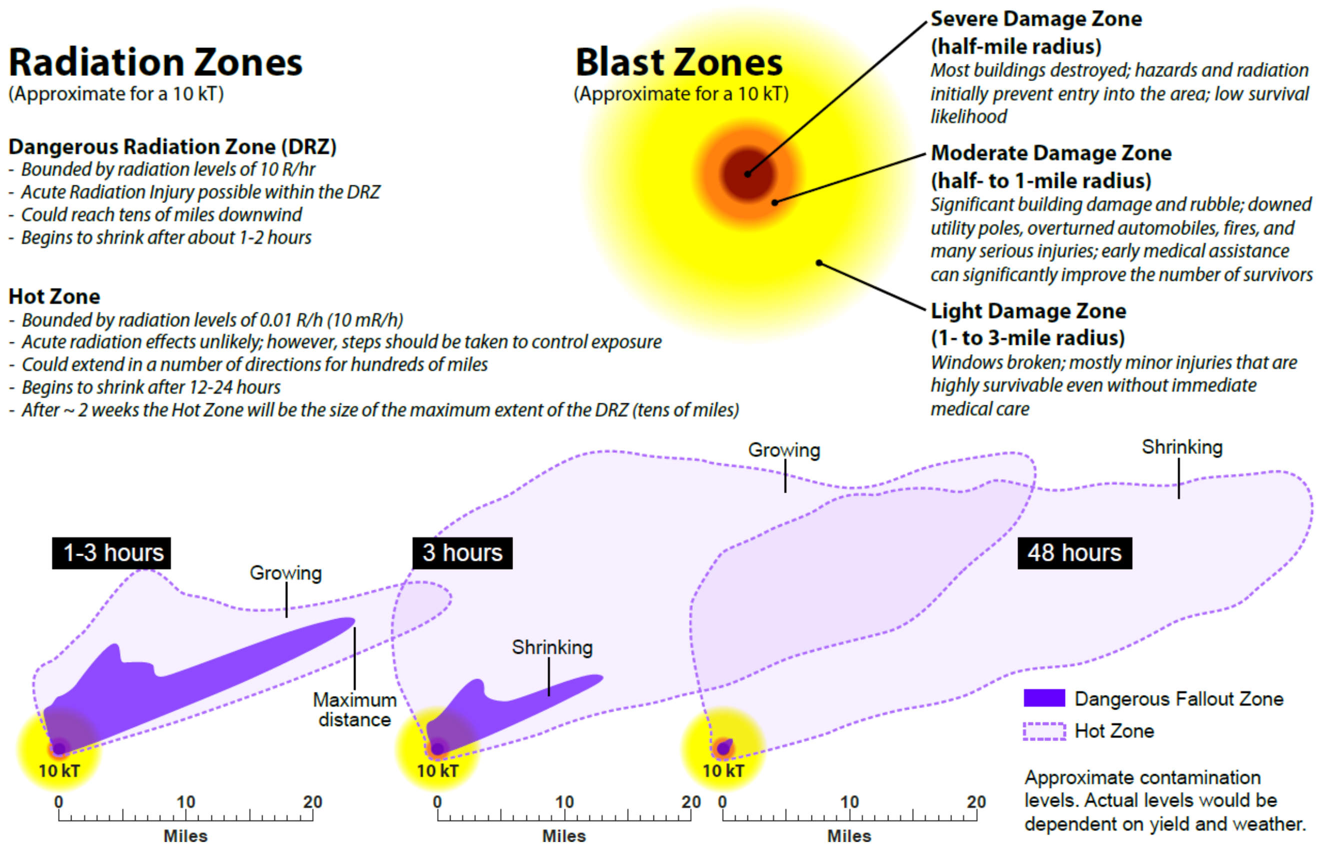


Figure 18: Depictions and Descriptions of the Five Planning Guidance Zones

2.1. Hazard Zones

This document defines five key radiation and blast zones for planning response operations and prioritizing actions. Each zone has different response priorities and survival implications. Radiation zones will overlap blast zones and initially grow over time, as fallout deposits downwind, then shrink as the radiation decays.

2.1.1. RADIATION ZONES

As described in Chapter 1, residual radiation from the nuclear detonation can create persistent radiation hazards, long after initial effects have subsided. Fallout is generated when radioactive material mixes with dirt and debris pulled up during a near-surface explosion. Because of uncertainty about the magnitude and direction of fallout, an initial “Get Inside, Stay Inside, Stay Tuned” instruction should be initially provided to everyone within 50 miles, unless specific fallout hazard areas have been identified.

Radiation levels change rapidly over time. Fallout accumulates downwind then rapidly decays, emitting over half of its energy in the first hour. After the first few hours, radiation levels drop, allowing responders to access previously restricted areas.

Responders can perform their duties while minimizing radiation exposure risks, provided they have appropriate knowledge and equipment.[20] For example:

- Responders without radiation detection instruments should shelter until informed it is safe to respond.
- Responders with radiation detection instruments should shelter and use their radiation detection equipment to monitor and report local radiological conditions:
  - If outdoor radiation levels exceed 10 R/hr, responders should continue to shelter (unless there is a time-critical, life-safety issue, such as a fire, building collapse, or medical emergency).
  - If outdoor radiation levels are below 10 R/hr, responders should assess their immediate area for hazards. However, for the first few hours, responders should stay near adequate shelters and closely monitor radiation levels. If radiation levels increase rapidly, responders should shelter immediately.

- Emergency workers should keep individual radiation exposures as low as reasonably achievable (as low as reasonably achievable [ALARA])[21] without hindering their ability to save and sustain life.
- First responders may not have appropriate radiation monitoring equipment. For details regarding emergency worker safety strategies, including radiation detection and monitoring, see Chapter 2, Section 2.2: Emergency Worker Safety and Appendix 2.1: Alternative Techniques to Determine Dose.

Dangerous Radiation Zone (DRZ)

Description: Area where radioactive contamination creates outdoor exposure rates above 10 R/hr. Radiation levels are high enough to cause radiation injury or death if people are exposed for extended periods. This zone reaches maximum size in the first few hours then shrinks rapidly as radioactive fallout decays.

Public actions: "Get Inside, Stay Inside, Stay Tuned" for at least 12–24 hours, unless threatened by fire, building collapse, medical needs, or other immediate threats. Seek adequate shelter in basements or

[20] These bullets are derived from NCRP Commentary No. 179 – Guidance for Emergency Response Dosimetry, and reprinted with permission of the National Council on Radiation Protection and Measurements, ncrponline.org/publications.

[21] The guiding principle of radiation safety is ALARA. This principle means that even if it is a small dose, if receiving that dose has no direct benefit, you should try to avoid it. For more information, visit the CDC website on the radiation ALARA principle.

the center of larger, dense buildings (as described in Chapter 3). Any shelter is better than being outside for extended periods. Stay tuned for public announcements about hazard areas and evacuations.

Responder actions: Shelter in place or avoid this area unless undertaking critical, planned protection activities for large populations. Responders in this zone need radiation monitoring equipment to alert them of excess exposure. Wear personal protective equipment (PPE) appropriate for all hazards present, including non-radiological hazards. Emergency workers should only enter this area after being fully informed of the risks.

Additional information:

- External exposure dominates total radiation dose. Inhalation or ingestion of radioactive particles is a secondary concern. Inhalation PPE may still be needed for other hazards (e.g., smoke and dust), though this should not be a priority for radiation-related concerns.
- Precipitation and weather may create irregular patches of dangerous radiation levels, sometimes well outside the main fallout areas. Use radiation detection equipment whenever possible to verify conditions and identify these areas.
- In the DRZ, lacking adequate shelter can cause radiation injuries. Adequate shelter is described in detail in Chapter 3 and significantly shields those within from radiation. Adequate shelter reduces radiation dose by a factor of 10 or more.
- Emergency worker dose guidelines: Based on the EPA *PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents*, the dose guideline for lifesaving activities is 250 mSv (25 rem) for responders over the course of the entire response. The dose guideline for protection of property is 100 mSv (10 rem) for the incident. The occupational dose limit of 50 mSv (5 rem) per year applies to all other work. These guidelines can be exceeded for lifesaving actions under certain conditions (see protective action guidelines [PAGs] for details regarding these conditions).
- Health and safety operational authorities should establish control points for maximum responder doses and dose rates, beyond which operations require justification for continued responder exposure.
- Most fallout contamination on a person can be eliminated by a change of clothes/footwear and brushing off or wiping exposed skin.
- When evacuating, people should move away from the detonation location and areas with the highest fallout concentration.

Refer To

References regarding emergency worker safety, such as dose guidelines:

- *PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents:* *www.epa.gov/sites/production/files/2017-01/documents/epa_pag_manual_final_revisions_01-11-2017_cover_disclaimer_8.pdf*
- Radiation Emergencies: Information for Emergency Responders: www.cdc.gov/nceh/radiation/emergencies/first_responders.htm
- Radiation Emergency Preparedness and Response: www.osha.gov/emergency-preparedness/radiation/response

Hot Zone (HZ)

Description: Outdoor exposure rates are between 0.01 R/hr (10 mR/hr) and 10 R/hr. Radiation levels are low enough that there is no immediate danger, but high enough to warrant protective measures that reduce long-term health risks, including cancer. This zone may extend in multiple directions for hundreds of miles. It will likely reach its maximum size after about a day, then shrink. Weather and terrain will likely create an irregular shape, including hot spots, due to non-uniform dispersal or precipitation.

Public actions: "Get Inside, Stay Inside, Stay Tuned" for at least 12–24 hours unless threatened by fire, building collapse, medical needs, or other immediate threats. Ideally, shelter in basements or the center of larger, dense buildings (as described in Chapter 3). Any shelter is better than being outside for extended periods of time. In many areas, fallout will arrive an hour or more after the detonation. Stay tuned for public announcements about hazard areas and evacuations.

Responder actions: Monitor radiation levels. Minimize radiation exposure by limiting time spent outdoors. Wear PPE appropriate for all hazards present, particularly non-radiological hazards. Support more heavily impacted zones (LDZ, MDZ) if possible and do not delay local emergency response activities.

Additional Information:

- Radiation exposure should be kept ALARA. Sheltering, possibly followed by a delayed evacuation, is recommended, even at long distances downwind. Seek adequate shelter if possible (based on guidance in Chapter 3).
- Radiation monitoring equipment should be used in the HZ to let responders know when they are nearing or entering the DRZ.
- The HZ will overlap the SDZ, MDZ, and LDZ. In overlap areas, public and responder actions should be driven by damage zone hazards and priorities.

- Precipitation may create HZ patches hundreds of miles from ground zero; these are difficult to predict with modeling tools. Use radiation detection equipment whenever possible to verify conditions.
- Medical emergencies take precedence over radiological concerns in the HZ. Lifesaving operations should not be delayed for radiation exposure/contamination concerns.

Where the HZ overlaps with the LDZ or MDZ, response activities should be guided by LDZ and MDZ priorities. Radiation monitoring should be performed to ensure responders avoid entering the DRZ unnecessarily.

There will be a large region where elevated radiation can be detected. Although these radiation levels may generate public concern, outside the DRZ and HZ no immediate action is warranted.

2.1.2. BLAST DAMAGE ZONES

As described in Chapter 1, the blast wave will damage buildings and infrastructures, with decreasing severity farther from ground zero. For planning and response purposes, the damagehas been categorized into three zones—the SDZ, MDZ, and LDZ.

Blast damage mechanisms and the area impacted vary based on terrain, urban building density, HOB, yield, and atmospheric conditions. Subsequently, responders must determine blast damage zones through visual observations of damage. Models provide estimated zones for planning; however, actual zones will not be as clearly defined as model results imply. To highlight expected uncertainty and variability, many graphics in this document do not have sharp boundaries or transitions. To provide basic, generic parameters, this document assumes a nominal 10 kT detonation. While distances would vary, the zone descriptions apply to any size nuclear explosion.

Refer To

What to do DURING: www.ready.gov/sites/default/files/2020-11/ready_nuclear-explosion_fact-sheet_0.pdf

Severe Damage Zone (SDZ)

Description: Area where few, if any, buildings remain standing or structurally sound. Access and movement in the area will be extremely limited due to rubble and debris. Those outside at the time of detonation will not survive. People in robust structures or underground areas may survive but will be at risk due to building collapse and radiation exposure. Underground infrastructure damage inside the SDZ could affect areas outside of the SDZ (such as damaged water pipes in the SDZ affecting the water pressure in other areas).

Figure 19: The destruction of the World Trade Towers on 9/11/2001 is similar to the type of damage that might be seen in the SDZ.

Observables and considerations

- The SDZ may have a radius of ~½ mile for a 10 kT detonation.
- Responders should enter this zone with great caution and only to rescue known survivors after assessment of potential radiation exposure and other hazards.
- Very few people will survive in the SDZ. Some people within large, protective structures; underground parking garages; or subway tunnels at the time of the explosion may survive the initial blast.
- Timely response is unfeasible in the SDZ—response operations should focus first on the MDZ.

Blast

- Few, if any, buildings are expected to be structurally sound or even standing.
- Approaching ground zero, all buildings will be destroyed and the streets will be impassable due to rubble, which can reach 30+ ft deep.

Radiation

- Those outdoors at the time of detonation may receive a lethal dose of initial radiation and even those within buildings can receive a significant dose.
- Underground areas, such as subterranean parking garages or subway tunnels, can protect against radiation.

- Residual radiation levels from ground activation and fallout outdoors will likely be dangerous.

Thermal

- The thermal pulse will ignite fires and cause lethal burns to those with a line of sight to the fireball.
- Blast wave effects may prevent further fire growth by effectively blowing out fires started by the thermal pulse and burying combustible materials.

EMP

- The EMP may damage or disrupt electronic equipment. Some responder commercial band AM/FM radios will still be able to receive signals from transmitters outside the area.
- Power and other infrastructure will be out due to blast and EMP effects.

Public actions: Stay indoors unless in danger from fire, building collapse, medical emergency, or other imminent threat. Allow 12–24 hours for radiation levels to decay, and then use protected escape routes (e.g., connections between buildings, tunnels, core areas within buildings, sidewalk overhangs, and the shortest distances between adjacent structures), if possible.

Responder actions: Due to likely hazardous outdoor radiation levels and the technical nature of mounting a response in an area of near complete destruction, this zone is not a priority and response resources should be used elsewhere. Responders entering the SDZ should wear PPE appropriate for the non-radiological hazards (e.g., fire, sharps, hazardous dust, smoke) and use high-range radiation monitoring instruments (see Appendix 2.1 for instrument information).

> Response within the SDZ should not be attempted until radiation dose rates have dropped substantially in the days following a nuclear detonation. When more resources become available later in the response, the radiation dose rates within the SDZ should be reassessed. All response missions must be justified to minimize responder risks.

Moderate Damage Zone (MDZ)

Description: Area with substantial damage to most structures and minor damage to heavily reinforced structures. People in this zone may experience injuries or death from blast over-pressure, building collapse, flying debris, fires, and thermal burns. Radiation injuries and deaths may occur, even following incidents without significant fallout.

Figure 20: Example of MDZ-Like Blast Damage

Observables and considerations

- Building damage is substantial in the MDZ. MDZ damage may be ~ 1 mile from ground zero for a 10 kT nuclear explosion.
- Many casualties in the MDZ will survive and will benefit the most from urgent medical care, compared to survivors in other zones.
- A number of hazards should be expected in the MDZ, including elevated radiation levels, downed power lines, ruptured gas lines, unstable structures, sharp metal objects, broken glass,toxic dust from collapsed buildings, ruptured fuel tanks, and other hazards.
- Visibility in much of the MDZ may be limited due to dust raised by collapsed buildings and smoke from fires.
- Water infrastructure may be damaged, limiting firefighting operations.

Blast

- Buildings in the MDZ will have significant structural damage and blown-out interiors. Downed utility lines, overturned automobiles, caved roofs, collapsed buildings, and fires will be present. Sturdier buildings (e.g., reinforced concrete) will remain standing; however, other commercial and multi-unit residential buildings may have fallen or be structurally unstable, and many wood frame houses will be destroyed. For additional information about how different structures will fare, see Chapter 3.
- Substantial rubble and disabled vehicles are expected in the streets, making evacuation and vehicle passage difficult or impossible without street clearing. Closer to ground zero, rubble will completely block streets and require heavy equipment to clear.

Radiation

- For near-surface detonations that generate fallout, dangerous radiation levels will exist downwind of ground zero within the MDZ.
- Initial radiation may cause significant radiation dose to those outside during the detonation, especially for yields less than 10 kT.

Thermal

- For air bursts and yields greater than 10 kT, the thermal pulse can ignite fires and cause lethal burns to those with line of sight to the fireball.
- Fires will be a major concern in the MDZ. Depending on weather conditions, these fires can spread quickly and may coalesce into a mass fire.

EMP

- The EMP may damage or upset some electronic equipment in this area; however, most battery-operated equipment should work after power cycling (turning off, then on again).
- Unprotected equipment plugged into wall outlets may be damaged due to power surge.
- Commercial band AM/FM radios will be able to receive signals from transmitters outside the area.
- Power will likely be out in this area.

Public actions: Seek immediate shelter in a large, dense building. Stay sheltered unless threatened by fire or building collapse. Tune in to local radio to determine radiation hazard. Evacuate if directed or experiencing life-threatening conditions, such as impending building collapse, fire, or medical emergency.

Responder actions: The MDZ has the greatest lifesaving potential through early responder actions. Monitor radiation levels and avoid the DRZ. Perform rescue and lifesaving activities, such as firefighting, when possible. Wear PPE appropriate for the non-radiological hazards (e.g., fire, sharps, hazardous dust, smoke) and adhere to the radiation monitoring guidance below.

- MDZ Outside of the DRZ (i.e., exposure rate less than 10 R/h): Manage fires and support evacuation. Fire and building collapse are an immediate and direct threat in this zone. Response organizations must clear and maintain safe evacuation corridors. There will be many serious injuries that require evacuation. Use radiological monitoring equipment that alerts users if they approach a HZ or DRZ. If working in the HZ, follow the responder protection measures in the HZ description above.

- MDZ with DRZ Overlap (i.e., exposure rate greater than 10 R/h): Manage fires remotely, if possible, recommend sheltering if safe to do so, and enable public egress to escape life-threatening conditions. Minimize outdoor responder activities. Monitor radiological conditions and operate outside the DRZ when possible. Only conduct short, focused, and critical activities, to avoid unnecessary exposure. Access to the DRZ will increase over time as radiation levels decay. Responders in this zone should have high range radiation monitoring equipment that alerts them to high exposure rates and excessive dose.

In the MDZ, fire and building collapse represent an immediate threat. Response organizations should perform defensive tactics to maintain evacuation corridors and facilitate evacuation in areas when safe to do so.

The MDZ should be the focus of early life-saving operations. Response activities should focus on evacuation of endangered populations and medical triage of the injured.

Light Damage Zone

Description: Area where glass windows can be broken with enough force to injure those near them. Most structures will be externally damaged, but few will experience structural damage (see Figure 21). (Note: Glass windows will be broken over a much larger area, but are unlikely to result in injury outside this zone.)

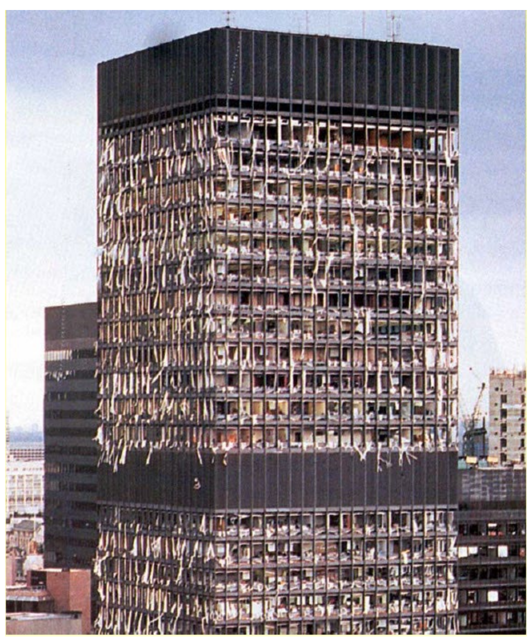


Figure 21: Example of LDZ-like Blast Damage

Observables and considerations

- Nearly all windows in this area are broken (even those facing away from the blast).Flying debris will cause a significant number of injuries.

- LDZ damage may extend to ~3 miles from ground zero for a 10 kT nuclear explosion. Damage in this area will vary, because shock waves will rebound off buildings, terrain,and the atmosphere.

Blast

- The blast will damage unreinforced structures and cause injuries. Most injuries are not life-threatening, and self/outpatient care may be adequate.

Radiation

- For near-surface detonations that generate fallout, dangerous radiation levels may exist downwind of ground zero within the LDZ. Fallout will likely take 10 minutes or more to arrive.
- Initial radiation is unlikely to cause significant exposure (even to those outside), except for yields less than 1 kT. (For more information, see Figure 7 in Chapter 1.)

Thermal

- For air bursts and yields greater than 10 kT, the thermal pulse can ignite fires and cause lethal burns to those with a line-of-sight to the fireball in the portion of the LDZ closest to the detonation.
- Fires will be a major concern in the LDZ. Depending on weather conditions, MDZ fires can quickly spread into the LDZ and may coalesce into a mass fire.

EMP

- Most battery-operated equipment will not be damaged, but some equipment may lose some functionality. Battery-operated equipment should work after power cycling (turning off, then on again).
- Equipment plugged into wall outlets without a surge protector may be damaged due to power surges.
- Commercial band AM/FM radios will continue to receive signals from transmitters outside the area.
- Power will likely be out in most, if not all, of the LDZ, due to power grid destabilization.

Public actions: Seek adequate shelter in basement areas or the center of larger concrete or reinforced brick buildings. There will be 10 minutes or more after the detonation to find adequate protection before fallout arrives. Stay sheltered 12–24 hours unless provided alternate instructions or if you are in immediate danger from fire, building collapse, medical emergency, or other imminent threat.

Responder actions: Treat survivors with serious injuries and direct patients with minor injuries to triage sites. Support response activities in the MDZ. Monitor radiation levels and avoid the DRZ.

- LDZ outside of the DRZ (i.e., exposure rate less than 10 R/h): Manage fires, clear routes, and advise shelter, but do not prevent self-evacuation. Evacuation is not required to mitigate the radiological hazard but may be warranted due to unsafe shelter conditions (weather, fire, medical emergency, smoke, etc.). Responders should maintain evacuation corridors and treat the injured. If elevated radiation levels (i.e., HZ) occur, keep people moving out of the contaminated area. Identify casualty collection points and Radiation Triage, Treatment, and Transport (RTR) 1 sites. (For information on RTR sites, visit Chapter 4.)

- LDZ with DRZ overlap (i.e., exposure rate greater than 10 R/h): Manage fires (if needed to prevent spread) and recommend sheltering if safe to do so. Minimize outdoor responder activities. Monitor radiological conditions and operate outside the DRZ when possible. Only conduct short, focused, critical activities in the DRZ. Defer all non-immediate response needs. If fire suppression is needed in the DRZ, consider approaches that don't require the physical presence of responders (e.g., helicopter techniques).

Additional LDZ information:

- The uninjured and those with minor injuries should seek adequate shelter.

- Crashed and abandoned vehicles will block roads, preventing or slowing emergency vehicle access.

- Where safe to do so, self-treatment and community-organized first aid (such as RTR 1 sites described in Chapter 4) should be promoted in this zone.

Most of the injuries incurred within the LDZ will not be life-threatening. If injured survivors are mobile, they should be directed to RTR sites (see Chapter 4).

2.2. Emergency Worker Safety

The National Council on Radiation Protection and Measurements (NCRP) defines emergency workers as those who would be called to assist with response to a radiological or nuclear incident, acknowledging that most emergency workers have jobs that do not routinely expose them to significant radiation.[22] Emergency workers include law enforcement personnel, firefighters, emergency medical service providers, and infrastructure repair personnel, among others.

[22] This definition is derived from NCRP Report No. 179, *Guidance for Emergency Response Dosimetry*, and reprinted with permission of the National Council on Radiation Protection and Measurements, ncrponline.org/publications.

To manage emergency worker safety, incident response organizations should adhere to the National Incident Management System (NIMS) and Incident Command System (ICS). At all levels of government, the ICS is the emergency response standard and facilitates safe operations in highly hazardous environments.

IMAAC can provide models indicating fallout deposition and dangerous radiation areas within the first hour after a nuclear detonation. IMAAC models are available to FSLTT authorities.[23] As described in Chapter 1, initial products are only estimates and will likely have great uncertainty about affected areas, but accuracy will improve over time.

Predictive modeling alone is not sufficient for making worker protection decisions. Radiation measurements and fallout cloud observations are critical to confirm fallout-affected areas and make informed protective action decisions.

Radiation measurements and zone awareness are the primary measures to limit and avoid radiation exposure. Emergency worker dose can be monitored and controlled in a variety of ways, including worker accountability practices and stay time limits.[24]

2.2.1. EMERGENCY WORKER SAFETY STRATEGY

An emergency worker safety program must be integrated into overall operational planning. Emergency worker safety programs must review operational tasks, analyze hazards posed to workers, and establish necessary protections. First responders cannot be expected to have radiological expertise; yet in the context of an emergency, they must plan and manage response activities that involve radiation exposure. Under emergency conditions, applying ALARA can be viewed as making reasonable and practical efforts to both maintain radiation exposures below levels causing acute health effects and reduce the risk of stochastic effects (i.e., risk of cancer later inlife), while maximizing lifesaving operations and protecting critical infrastructure.

Emergency worker safety programs should adopt dose guidelines for “emergency exposure situations where an informed, exposed individual is engaged in volunteered life-saving actions or is attempting to prevent a catastrophic situation.”[25] These guidelines are not limits—rather, they identify conditions where higher doses may be justified. Once urgent, lifesaving actions are no longer

[23] For information about how to access and request IMAAC products, please visit IMAAC.

[24] Derived from NCRP Commentary No. 19, *Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism*, and reprinted with permission of the National Council on Radiation Protection and Measurements, ncrponline.org/publications.

[25] Paragraph 247 of ICRP 103.

required, appropriate regulatory limits should be applied. Emergency responder guidelines can be found in Table 4.

Table 4: Responder Dose Guidelines[26]

Guideline	Activity	Condition
50 mSv (5 rem)	All occupational exposures	All reasonably achievable actions have been taken to minimize dose.
100 mSv (10 rem)[a]	Protecting valuable property necessaryfor public welfare	Exceeding 50 mSv (5 rem) is unavoidable and all appropriate actions are taken to reduce dose. Monitoring is available to project or measure dose.
250 mSv (25 rem)[b]	Lifesaving or protection of large populations	Exceeding 50 mSv (5 rem) is unavoidable and all appropriate actions are taken to reduce dose. Monitoring is available to project or measure dose.
>250 mSv (>25 rem)	Lifesaving or protection of large populations	All conditions above and only for people fully aware of the risks involved
500 mGy (50 rad)	Lifesaving or protection of large populations	NCRP recommends, when the cumulative absorbed dose to an emergency responder reaches 0.5 Gy (50 rad), a decision be made on whether to withdraw the emergency responder from the HZ. NCRP considers the 0.5 Gy (50 rad) cumulative absorbed dose a decision dose, not a dose limit.

[a] For potential doses > 50 mSv (>5 rem), medical monitoring programs should be considered.
[b] In the case of a very large incident, such as an improvised nuclear device (IND), incident commanders may need to consider raising the property and lifesaving response worker guidelines to prevent further loss of life and massive spread of destruction.

The *PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents* advises exposures below 50 mSv (5 rem) for worker protection whenever possible. However, when there is an overwhelming and immediate need, additional guidelines may be considered.

[26] This table is adapted from NCRP Commentary No. 19, *Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism,* and reprinted with permission of the National Council on Radiation Protection and Measurements, ncrponline.org/publications.

Refer To

PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents: www.epa.gov/sites/production/files/2017-01/documents/epa_pag_manual_final_revisions_01-11-2017_cover_disclaimer_8.pdf

The NCRP defines decision points as, "when the cumulative absorbed dose to an emergency responder reaches 50 rad, a decision must be made on whether or not to withdraw the emergency responder from the HZ. NCRP considers the 0.5 Gy (50 rad) cumulative absorbed dose a decision dose, not a dose limit."[27]

Refer To

Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers: ncrponline.org/wp-content/themes/ncrp/PDFs/2017/NCRP_Report_No.165_complimentary.pdf

Action Item

Develop and disseminate a comprehensive emergency worker safety program for nuclear incident response.

Emergency Response Dosimetry

The first 72 hours after a nuclear detonation will be a period of austere conditions when some emergency workers will not be fully equipped to measure and control their radiation dose. This will be a chaotic time, and public health and safety agencies may be forced to adapt or modify their routine practices and expectations. While exceptions may be necessary in the earliest phase of response, controlling the first responder and emergency workers exposures is critical.

[27] Derived from NCRP Report No. 179, *Guidance for Emergency Response Dosimetry* and reprinted with permission of the National Council on Radiation Protection and Measurements, ncrponline.org/publications.

Emergency worker dose assessments can be performed in a variety of ways with a varietyof equipment or techniques.[28]

> "Dosimetry is defined as the science or technique of determining radiation dose. Strictly speaking, involving measured quantities, but also used informally to mean 'dose assessment' (i.e., involving measurements and/or theoretical calculations)."[29]

Radiation Detection and Monitoring Instrumentation

When responding to a nuclear detonation, responders need an instrument that alerts users of hazardous radiation levels and accumulated exposures. There are a variety of radiation detection and monitoring instruments, designed for various work environments and levels of radiation, likely to be encountered. Appendix 2.1 provides additional information on the appropriate selection of equipment and their limitations.

Assigning a Dose to Emergency Workers

Assigning a dose to an individual does not require specific equipment or devices, but it should be based on the best obtainable information. Alternate techniques for determining radiation dose include monitoring and dose reconstruction:

- Monitoring: Using radiation detectors that provide real-time radiation exposure rates and, where possible, cumulative exposures.
- Dose Reconstruction: Retrospective dose assessment based on representative individuals/populations.

Alternate techniques for determining emergency worker dose are discussed in Appendix 2.1: Alternative Techniques to Determine Dose.

> With proper planning, emergency worker dose control and monitoring can be adequately performed with older, less-capable equipment and repurposed preventative radiological/nuclear detectors.
>
> Monitoring dose rates and tracking time and location information for each emergency worker can often suffice as basic emergency worker dosimetry.

[28] Derived from NCRP Report No. 179, *Guidance for Emergency Response Dosimetry* and reprinted with permission of the National Council on Radiation Protection and Measurements, ncrponline.org/publications.

[29] Derived from NCRP Report No. 179, Guidance for Emergency Response Dosimetry, and reprinted with permission of the National Council on Radiation Protection and Measurements, ncrponline.org/publications.

Refer To

Biological assays are utilized to assess an individual's dose. They may be referred to as biodosimetry or biodose. This is further detailed in Chapter 4: Acute Medical Care.

Personal Protective Equipment (PPE)

External exposure from penetrating radiation is the primary hazard, as opposed to inhalation or ingestion. Penetrating radiation can penetrate through clothing, walls, protective suits, cars, etc. Based on observations from past nuclear weapon tests, respiratory protection is not generally required to address fallout hazards (Levanon & Pernick, 1988). Respiratory protection should be selected based on non-radiological hazards, such as smoke, dust, or vapors.

Typical HAZMAT protection, like protective suits and respiratory protection, does not mitigate penetrating radiation. Bulky PPE may even increase responder doses because it may slow responders down, increasing the time needed to accomplish the mission and exposing them for longer periods.

PPE selection should be based on the non-radiological hazards (fires, toxic industrial chemicals, sharp debris, etc.) in damage zones. For the radiological hazard, the most important equipment is a radiation detector that alerts workers to radiation levels of concern.

The National Institute of Occupational Safety and Health (NIOSH) prepared guidance on selecting appropriate PPE for response to terrorism incidents involving CBRN incidents. Effective planning must ensure that the emergency workers have access to the appropriate PPE for the activities they are performing during the response.

Refer To

Guidance on Emergency Responder Personal Protective Equipment (PPE) for Response to CBRN Terrorism Incident: www.cdc.gov/niosh/docs/2008-132/pdfs/2008-132.pdf

Firefighter turnout gear and anti-contamination clothing can ease decontamination, but time-critical, lifesaving activities shouldnot be delayed if such items are not available (assuming other hazards at the scene do not require such PPE). Following a nuclear detonation, many non-radiation hazards will be present. Fires, toxic industrial chemicals, and sharp debris are just a few examples of hazards that should be considered when working in the SDZ, MDZ, and LDZ.

2.3. Critical Infrastructure Decontamination

In the early phases of the response, infrastructure decontamination should be limited to infrastructure necessary to accomplish lifesaving missions and stabilize Community Lifelines. The Community Lifelines are a FEMA framework representing a core set of services fundamental to community function. There are seven Community Lifelines—Safety and Security; Food, Water, Shelter; Health and Medical; Energy (Power & Fuel); Communications; Transportation; and Hazardous Materials. Community Lifeline services and components include healthcare facilities, power plants, water treatment plants, airports, bridges, and evacuation routes. For a community to recover from a radiological or nuclear incident, all Community Lifeline components must be stabilized, including any necessary decontamination. Contaminated infrastructure should be prioritized based on estimated radiation exposure rates to determine if postponing decontamination is preferable. For more critical infrastructure decontamination information, see Appendix 2.2: Decontamination of Critical Infrastructure.

Figure 22: FEMA's Community Lifelines represent a set of core services necessary for community function.

> **Refer To**
>
> *Community Lifelines Implementation Toolkit* explains the seven different lifelines and their subcomponents, highlighting key infrastructure to consider during emergency response.
>
> www.fema.gov/sites/default/files/2020-05/CommunityLifelinesToolkit2.0v2.pdf

2.4. Waste Management

Following the detonation, an enormous quantity of contaminated, HAZMAT, and uncontaminated waste will be generated. Nuclear incident response plans must include waste management priorities and guidelines to address this waste. FSLTT waste management personnel should be involved in planning and response activities to identify holding/storage areas early in response. Officials must assess their local waste management asset inventory to support immediate recovery activities. Waste staging and holding location plans must extend beyond debris segregation and storage, to include screening debris for human remains, ensuring site security, assessing environmental and human health impacts, etc. For more information on waste management planning, see Appendix 2.3: Waste Management Operations.

Action Item

Include waste management priorities, methods, and inventory in nuclear incident response plans.

Refer To

Planners and emergency response officials must work with waste management personnel in their district when planning and responding.

Plan for decontamination of critical infrastructure and waste management operations to support extended response activities.

3. Shelter & Evacuation

Sheltering is one of the most, if not the most, important protective action that affected populations can take prior to or in the first few hours after a nuclear explosion. Sheltering can save lives by protecting people from blast hazards, thermal injuries, prompt radiation, radioactive fallout, and the inhalation of dust and smoke. To assist people in rapidly sheltering, planners must publicize shelter criteria, identify mass care shelters, and develop key messages. Following a nuclear detonation, the primary goal of sheltering and evacuation is to reduce the number of people exposed to life-threatening situations, such as high levels of radiation, medical emergencies, and fires.

A nuclear detonation creates many simultaneous hazards, as noted in Chapter 1. When faced with multiple, competing hazards, priority should be given to immediate, rather than longer term, threats. As a practical example, even in the DRZ people should leave a burning building. This guidance accepts that the risk of delayed health effects (due to radiation exposure) is lower than the risk of immediate death (due to the fire).

At the strategic level, a combined shelter and evacuation strategy has four steps:

1. Initially shelter (Get Inside, Stay Inside, Stay Tuned). In the absence of any information, sheltering provides protection against initial and fallout radiation, blast, thermal, and dust/smoke hazards. It also reduces the strain on response organizations and transportation infrastructure to better allow responders to access the incident and facilitate critical evacuations.
2. Develop situational awareness. Actions taken in the first few hours will have the biggest impacts on the overall number of lives saved. As such, prioritize identifying the following:
3. The response zones discussed in Chapter 2.
4. People in life-threatening situations such as fire concerns, medical emergencies, poor shelter quality in the DRZ, and building structural issues.
5. Potential evacuation routes and evacuation support capabilities.
6. Fire control and suppression capabilities.
7. Focus early (<24hr) response actions on mitigating immediately life-threatening situations, such as:
8. Moving poorly sheltered people in the DRZ to locations with better shelter or lower radiation hazards.
9. Fire control/suppression in areas where people are sheltered.
10. Evacuating people in areas where immediate threats outweigh evacuation hazards, such as those in the DRZ with inadequate shelter.

11. As time allows (greater than 24 hr), replace shelter with other response actions. Shelter is inherently a short-term response. End shelter when it is safe to do so. Evacuate people located in places where hazardous conditions remain, such as the MDZ. Consider simply lifting the shelter-in-place order where the hazardous conditions no longer remain (e.g., outside the HZ) and general population movement does not otherwise hinder the response.

3.1. Timely Messaging

Officials issuing warnings may only have 15–30 minutes when the incident involves a ballistic missile attack. A nuclear detonation by a terrorist group may have no warning.

Incidents may occur without advance notice. Planners must ensure that as much of the sheltering plan as possible is prepared ahead of time.

Protective actions must be developed, communicated, and implemented quickly to enhance their lifesaving capabilities. Delays in issuing and implementing recommendations could result in unnecessary fatalities. Messaging guidance is described more in Chapter 6 and alerts, warnings, and notifications in Chapter 7.

The following guidelines are provided for planning purposes, to identify planning and resource needs.

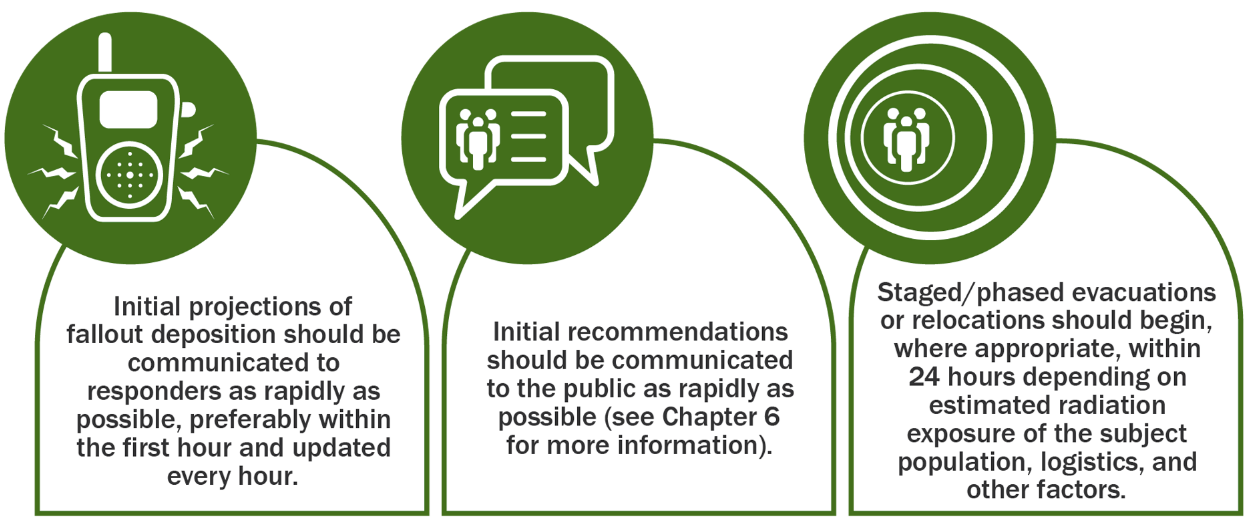


Figure 23: Shelter and Evacuation Planning Guidelines

Action Item

Prepare and approve emergency messaging prior to incidents to ensure swift dissemination of important information.

3.2. Adequate Shelter

As used in this document, to “Take Shelter” or “Get Inside” means going in (or staying in) the nearest underground or enclosed structure. An adequate shelter is a location that is heavy enough construction (e.g., concrete, brick, or cement) to mitigate blast effects (if sheltering prior to detonation) and reduce radiation exposure from fallout by a factor of 10 or more.

The best initial action immediately following a nuclear explosion is to take shelter in the nearest and most protective facility and listen for instructions from authorities.

Adequate shelter facilities for nuclear explosions must meet the following criteria:

- **Radiation**: The best radiation protection is underground (e.g., basements, subway tunnels, underground parking garages) or in the center of large, heavy buildings.
  - Most commercial buildings contain some adequate shelter.
  - Smaller single-family homes, particularly wood/steel frame houses, do not usually provide adequate protection above ground, though is still far better than being outside. Thicker-walled masonry buildings and residential basements generally provide adequate protection.
  - Cars do not provide adequate shelter.
- **Blast:** Underground areas or the center of buildings that have heavy construction (concrete, brick, or cement) mitigate blast effects. Protection from blast effects is not the primary purpose of sheltering, as populations may not have time to seek shelter from these effects, but it is important to consider ensuring shelters are structurally sound. If adequately warned of a possible detonation, seek shelter in the most structurally sound location available.
- **Dust and smoke**: Close windows and doors to minimize the amount of outdoor air being drawn into the building. Make sure to maintain enough ventilation to ensure adequate indoor air quality.

To protect against radiation fallout:

- Reduce time spent in radioactive areas
- Increase distance from source of radiation (fallout)
- Use dense materials (e.g., concrete, brick, or earth) as shielding

Action Item

When developing sheltering plans and guidance, evaluate adequate shelters and identify areas where shelter quality is generally poor. If feasible, target these areas of shelter improvement or develop plans for rapid evacuation.

Refer To

The Effects of Nuclear Weapons: www.osti.gov/servlets/purl/6852629

For sheltered individuals, the likelihood of acute radiation injury depends on both the outdoor radiation dose rate and the structure's protection factor (degree to which the dose is reduced; larger values provide better protection). Even minimally protective shelters outside the DRZ may be sufficient.

Penetrating radiation can be mitigated with shielding (placing dense building materials between people and radiation sources such as fallout) and increased distance from deposited fallout, including fallout on roofs. Adequate shelters reduce radiation doses by a factor of 10 or more and examples include basements; centers of large, multi-story structures; parking garages, and tunnels. Cars and other vehicles are not adequate shelters because they lack dense shielding material. Good shielding materials include concrete, brick, stone, and earth. Wood, drywall, and thin sheet metal provide minimal shielding. However, many layers of minimal shielding materials can also provide adequate protection (e.g., central rooms with many intervening drywalls). Structures do not need to be airtight to protect against fallout radiation, so buildings with minor damage can be used as shelters if they are structurally sound.

Shelters such as houses with basements, large multi-story structures, and parking garages or tunnels can generally reduce doses from fallout by a factor of 10 or more.

Vehicles and single-story wood frame houses without basements provide limited shielding and should not be considered adequate shelter.

3.3. Sheltering Guidance

The best initial action following a nuclear explosion is moving to and remaining within an accessible, adequate shelter away from windows, corners, doors, and outside walls. Individuals should plan to remain sheltered for at least 12–24 hours.

During the first minute after the detonation, being outdoors may result in death, severe burns, severe lacerations, and/or bone fractures due to blast overpressure and thermal hazards. The risk of these injuries increases with proximity to ground zero.

In the first few hours, lethal radiation levels may be present—even in areas tens of miles from ground zero and/or where fallout is not apparent. The hazard of the fallout radiation will decrease significantly over time, enabling safer evacuations. For additional sheltering protective action information, see 3.3: Sheltering Guidance. Emergency response officials may issue supplemental orders, such as early evacuation, to people in structures with poor shielding (e.g., wood frame residential structures). In addition, these individuals can reduce their radiation dose by transitioning to adequate shelters in the nearby area, ideally moving away from ground zero. The optimal time, from detonation, to stay in the first (poor quality) shelter will depend on the initial shelter protection factor and the travel time to the adequate shelter. The initial shelter time does not depend on the local radiation levels. When adequate shelters are nearby (within 15 minutes travel time), people in poor-quality shelters (protection factors = 2) should stay there no longer than 30 minutes from the detonation. For individuals in better shelters (protection factor = 4), people should stay for an hour or two prior to moving to a nearby adequate shelter.

Planners should evaluate adequate shelter options in their area. Planners must consider areas where adequate shelter is not readily available and develop alternative shelter options for those areas, including information and awareness messaging, evacuation plans, and self-protection measures. Planners in communities that generally lack adequate shelters should implement a public shelter program that provides adequate shelter. For example, in regions where residential basements are uncommon, planners must pre-designate large buildings as public shelters.

What Would You Do?

Put yourself in the shoes of someone in your jurisdiction who has been asked to shelter: Where is the closest place that provides adequate shelter? How long could you comfortably shelter at home or your workplaces? How long until you ran out of basic resources, medication, etc.? How would you receive additional instructions? How do the answers to these questions affect your response plan?

Figure 23 illustrates the radiation exposure reduction based on building type and location within the building.

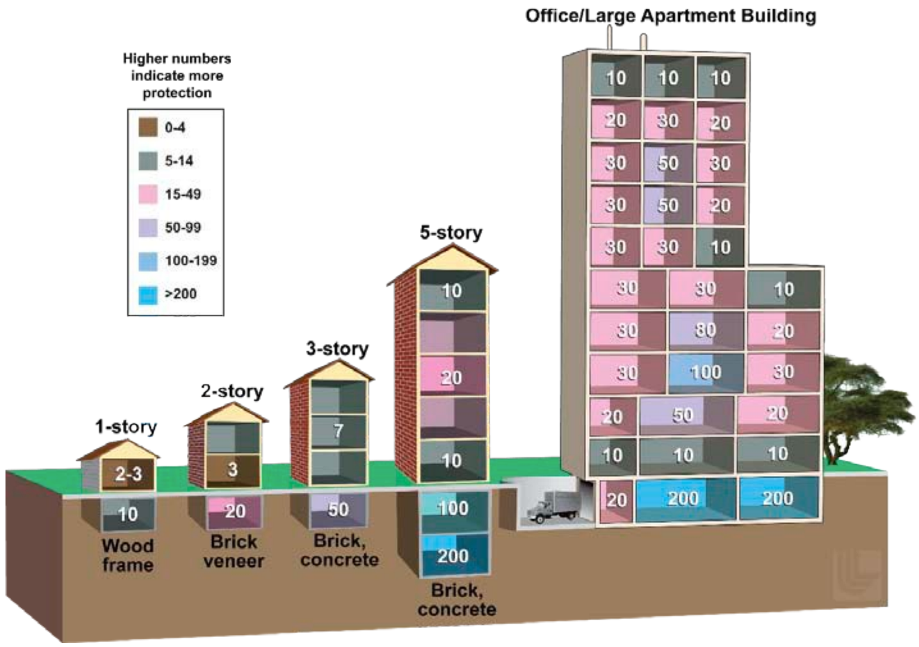


Figure 24: Buildings provide protective fallout shielding – Numbers represent a building protection factor. A building protection factor of 10 indicates that a person in that area would receive 1/10th of the dose of a person in the open. A building protection factor of 200 indicates that a person in that area would receive 1/200th of the dose of a person out in the open.

Action Item

- Address firefighting concerns in nuclear incident plans, including a prioritization structure for potentially limited water resources.
- When planning evacuation routes, ensure the routes do not obstruct critical transportation routes or response operations at large.

3.4. Situational Awareness

The zoned-based approach described in Chapter 2 is the foundation for shelter and evacuation decisions. To define these zones, planners must consider what resources are necessary to obtain accurate estimates of the fallout distribution and the building status. Since each information source only provides a partial characterization, planners should continuously incorporate new resources and information as they become available. It is critical to monitor for evolving hazards such as fallout deposition and fire initiation, spread, and possible coalescence.

Accurate fallout distribution and radiation dose rate estimates are critical for safe evacuations so that evacuees do not evacuate through locations with higher dose rates. Radiation-monitoring data from local responders can contribute to the situational awareness. Plume models, such as IMAAC's products, can project hazardous areas based on available information and parameters. Prediction accuracy will improve as measurements become incorporated into the models. Visual observations of the fallout cloud and its downwind drift can also be helpful. Fallout particles may be visible as fine, sandy material actively falling out as the plume passes or accumulating on clean surfaces (see Figure 10). Visible fallout particles may not be noticeable on rough or dirty surfaces, so their presence, or absence, cannot be used to directly estimate radiation dose rates.

After a nuclear detonation, the heat from the blast will ignite flammable and combustible materials—such as fuel, gas lines, furniture, and structural materials—particularly in the MDZ. Additionally, water and power outages due to the blast will inhibit firefighting capabilities. Thus, uncontrolled fires are anticipated and may spread from building to building, or house to house.

Action Item

Ensure plans include methods and processes for obtaining fallout projections. Exercise this process as necessary.

Coordination Opportunity

SLTT response officials must coordinate with federal entities to request fallout projections and protective action recommendations.

3.5. Evacuation Guidance

Sheltering is implicitly short term. Initial sheltering should be followed by staged, facilitated evacuation for those in fallout-impacted areas. Optimal shelter stay times can range from a few hours to several days and depend both on the local fallout dose rate and the radiation dose incurred during evacuation. Where possible, individuals should stay in an adequate shelter for the first 24 hours following detonation to prevent exposure to high levels of radiation. Evacuations should occur only after appropriate paths have been identified and cleared. Fire concerns should be closely monitored as rapidly evolving fires may warrant emergency evacuation of potentially impacted areas. Attempting to evacuate excessively large areas at a single time unnecessarily diverts resources from other response needs. Be aware that many people may choose to self-evacuate.

Action Item

When planning evacuation routes, ensure they do not obstruct critical transportation routes or response operations at large.

Unless threatened by fire or other immediate life-safety concerns, no evacuation should be attempted until basic information is available regarding fallout distribution and radiation dose rates.

When evacuations are executed, the priority should be to minimize the overall dose received. In many cases, this can be accomplished with lateral evacuation, where travel is at right angles to the fallout path (to the extent possible) and away from the plume centerline.

Evacuations should be prioritized based on fallout patterns, radiation dose rates, shelter adequacy, life-threatening hazards (e.g., fire and structural collapse), medical needs, needs of special populations such as children or pregnant women, sustenance resources (e.g., food and water), and operational considerations. Planners should especially prioritize individuals who face immediately life-threating situations. For these groups, early evacuation (starting less than 12 hours after the detonation) may be necessary. Uninjured individuals with adequate shelter and access to safe food and water are a low priority for early evacuation. Similarly, evacuation is a low priority for those outside of the dangerous radiation zone who have access to even minimally protective shelter (including single-story houses without basements) or for those who can quickly transition from poor to better shelters (e.g., moving from single-family home to a commercial structure such as a hotel). For individuals clearly outside the DRZ and HZ, consider simply lifting the shelter-in-place order (i.e., no evacuation) when appropriate.

When planning any evacuation, planners must consider:

- Responder and evacuee risks, including radiation exposure along the evacuation route
- The threat of fires or hazardous material exposure in the area
- Transportation resources (e.g., vehicles, public transit, rail, air, water)
- Ease of access and egress (including infrastructure damage to roads, bridges, and tunnels)
- Evacuation support resources
- Impact of self-evacuating populations

Refer To

The NRC NUREG/CR-7285, *Nonradiological Health Consequences of Evacuation and Relocation*, discusses the non-radiological health risks to evacuating populations that must be balanced with radiological hazards: www.nrc.gov/docs/ML2125/ML21252A104.pdf

3.6. Self-Evacuation

Responders will have limited control of the evacuation process immediately following a detonation, due to access limitations and fallout hazards.

Many individuals may self-evacuate, based on either official guidance or uninformed, spontaneous decisions. Self-evacuation is strongly discouraged due to the risks involved and because self-evacuees may clog transportation arteries, hindering the overall response. However, guidance should be provided to those who choose to self-evacuate despite warnings. Assistance may include providing self-evacuation instructions, including what direction to travel and when to go, as well as route conditions (e.g., rubble and debris in streets, collapsed bridges, and other obstacles). Self-evacuation guidance should also emphasize circumventing critical operations, when possible, to avoid complicating necessary evacuations and other response operations. Law enforcement can assist in keeping evacuations moving smoothly and protecting key infrastructure, including medical care centers that may otherwise be overwhelmed by self-reporting patients.

Action Item

Anticipate self-evacuations regardless of guidance. Provide guidance specifically for those self-evacuating.

Coordination Opportunity

Consider incorporating law enforcement into evacuation plans. Law enforcement can direct traffic and ensure critical infrastructure, such as health facilities, are not overwhelmed.

3.7. Contamination Concerns

Contamination occurs when fallout lands on clothing and exposed parts of the body (head, hands, etc.). It could also occur when moving through contaminated areas. Inhalation or ingestion of fallout is not a primary concern during the emergency phase of the response because of the large size of the fallout particles and their rapid decay. Crude respiratory protection, such as a cloth mask can further mitigate any concern. People may need rudimentary decontamination when they leave fallout areas or enter a shelter. Effective decontamination of people from fallout can be accomplished by brushing, removing, or changing the outer layer of clothing (including footwear) and wiping off exposed skin. For more information regarding contamination screening and decontamination, see Chapter 5.

4. Acute Medical Care

The large number of casualties caused by a nuclear detonation will likely overwhelm all local infrastructure, including local medical systems. Depending on the location of the detonation, tens or hundreds of thousands of people may require immediate lifesaving care and millions more may need some level of medical attention. Nevertheless, training and planning can save lives and prevent suffering.

Refer To

Numerous organizations provide relevant training, including:

- Centers for Disease Control and Prevention (CDC)
- Center for Domestic Preparedness (CDP)
- Counterterrorism Operations Support (CTOS) Center for Radiological Nuclear Training
- Department of Health and Human Services (HHS)
- Radiation Emergency Assistance Center/Training Site (REAC/TS)

The injuries seen will vary by location within the damage zones and fallout zones, with more severe injuries seen in the SDZ and MDZ than in the LDZ or in the parts of the HZ/DRZ that are outside of the damage zones. Much of the lifesaving work in the aftermath of the detonation involves finding and treating people who suffer injuries severe enough to lead to death without treatment but who are likely to recover with even basic treatment. This population is proportionally largest in the MDZ; though depending on specific location of the detonation, this population may be numerically bigger in the LDZ. Planners should work with federal agencies to understand the specific numbers of people that may fall into each category for their own jurisdiction under different scenarios.

Following a nuclear detonation, three major injury types are expected:

- Mechanical (physical) trauma
- Thermal burns
- Radiation injuries, including both cutaneous radiation injury (e.g., radiation burns) and acute radiation syndrome (ARS), both of which are discussed in greater detail in this chapter

These injuries can occur alone or in combination. Combined injuries, defined as radiation injury *in addition to* thermal burns and/or mechanical trauma, have a worse prognosis than simply adding the prognosis from each injury alone. Casualty triage for scarce resource environments typically prioritizes mechanical injury, then thermal burns, then radiation injuries. In the DRZ, where there is little mechanical or thermal injury, estimates of radiation exposure are triaged promptly.

Following a nuclear detonation, mass medical care activities will focus on identifying and treating radiation injuries (i.e., acute radiation syndrome [ARS]) that result from external exposure. Medically significant external exposure will affect more people and cause much more morbidity and mortality than internal contamination (radioactive material inside the body from ingestion, inhalation, or absorbed through skin breaks). Planners should understand the difference between external exposure, external contamination, and internal contamination (see Chapter 1 for more information).

Medical priorities in each of these damage zones are noted below.

- **SDZ:** Attempting to find, triage, and treat the few surviving casualties in the SDZ will be highly resource intensive, usually futile (i.e., casualties will be hard to find and are likely to die even with treatment), and extremely dangerous. It is not a priority until fallout decays and resources are available, after the first few days.

- **MDZ:** To provide the most effective help to the greatest number of victims, planners and medical responders should focus initial medical resources on casualties in the MDZ. Casualties in the MDZ have acute injuries that can be helped with the resources that will be initially available. Additionally, if responders are actively monitored (see Appendix 2.1: Alternative Techniques to Determine Dose), they can safely access MDZ casualties. Radiation levels in the MDZ will be below dangerous levels, except for downwind areas after a near-surface detonation.

- **LDZ**: Most casualties in the LDZ will be minor and can be effectively treated with a delay of a few days. Those with urgent, pre-existing conditions (e.g., renal failure on dialysis) or acute medical events (e.g., heart attacks and strokes) unrelated to the detonation will require immediate medical attention. There may also be severe trauma injuries in the LDZ caused by flying/falling debris and car accidents secondary to flash blindness. Similar to the MDZ, downwind areas of the LDZ may temporarily have dangerous radiation levels after a near-surface detonation.

Medical response planners should be familiar with basic medical and radiation response guidance, including:

- ICS and Hospital Incident Command System (HICS)

- NRIA to the Response and Recovery FIOPs

- Radiation Emergency Medical Management (REMM) website

- EPA Protective Action Guides (PAGs)

- Emergency Contacts for Help During Radiation Emergencies

4.1. Injuries: Identification, Triage, and Treatment

Injuries faced by medical responders following a nuclear detonation primarily fall into several different categories: mechanical trauma, thermal injuries, and radiation injuries. Medical responders must be prepared to handle the complications of these injuries, including microbial infections, and psychosocial and behavioral health effects caused by the detonation. Moreover, the ongoing medical needs of the evacuating and general population (e.g., medically required oxygen or dialysis) must be considered while treating those injured by the incident.

4.1.1. MECHANICAL TRAUMA

Mechanical trauma will result from the blast wave, building collapse, falling/flying debris, and car accidents. Triage, diagnosis, and treatment of mechanical trauma after a nuclear detonation may differ from that practiced in normal times due to (1) radiation and burns complicating the trauma, (2) austere conditions (scarce resources: staff, space, supplies, systems) and huge patient surge leading to alterations in standards of care, and (3) degraded infrastructure (Coleman & Weinstock, 2011; Coleman & Hick, 2018b).

Teams composed of various specialties will manage large numbers of orthopedic, general surgery, pulmonary, cardiology, ophthalmologic, hematologic, infectious disease, neurology, and psychological issues. Referral to expert centers may be necessary when possible. Diagnosing and treating mechanical trauma requires extensive medical equipment and supplies, including medical imaging equipment, supplies for wound cleaning, hemorrhage control, blood replacement, fluid replacement, pressors, antimicrobials, surgical venues, staff, and patient medical record implementation. In addition to equipment and supplies, a surge of personnel with specific expertise will also be necessary to handle the number of patients encountered, including personnel with expertise in radiation safety, infectious disease, and radiation and hematology-oncology. While functioning medical facilities will be able to support treatment of some of these injuries, the medical response plan should include the deployment of medical equipment, supplies, and personnel into receiving communities. As many with fatal traumatic injuries will die if they are not treated within 12 hours of their injury, medical response plans cannot rely solely on this deployment or the evacuation of patients. Planners should also consider bolstering the resources available at likely receiving medical centers as a preparedness activity, making more resources available after an incident.

4.1.2. THERMAL BURN INJURIES

Two types of thermal injuries occur from nuclear explosions: flash burns and flame burns. Flash burns occur due to the initial thermal flash from the detonation, while flame burns result from subsequent fires. Air detonations will cause a greater number of flash burns than ground detonations, as buildings will create shadow in the regions behind them. Thermal burns (inhalational burns in particular) also pose a hazard and significantly increase mortality when occurring alongside traumatic or radiation injury.

Figure 25: Flash burn victims from (a) Hiroshima showing pattern burns due to clothing patterns and (b) Nagasaki showing profile burns from clothing coverage (War Department, 1945).

Flash burns accounted for the overwhelming majority of burns sustained among survivors of Hiroshima and Nagasaki; 83–91% were due to flash alone, 6–15% were both flash and flame, and 2–3% were flame alone (Lebow et al., 1981).

Infections of large burns can be fatal if not debrided (detoxified or removed) within hours to days (Allgöwer et al., 2008). Similar to mechanical injuries, the medical response plan must be prepared to accommodate potentially large numbers of patients with burn injuries during the first few days following a nuclear detonation. Burns have a substantial requirement for continual care beyond the first treatment, as burns must be regularly debrided after the initial treatment. Like open mechanical injuries, burn wounds are also subject to infection (Church et al., 2006).

Thermal burns are characterized both by the surface area they cover and by burn depth. Burn surface area is measured relative to the total body surface area (TBSA), designated as percent TBSA (%TBSA). For additional information about TBSA and burn depth metrics, see Appendix 4.3: Burn Injuries.

There are currently only 139 self-identified burn centers in the U.S.,with approximately 1,800 beds (American Burn Association, 2019). Even a small nuclear detonation will likely overwhelm the available burn beds. Planners should identify which burn centers can serve their communities, consider how to effectively include burn centers in the planning process, and identify additional alternatives to support burn victims.

Action Item

Research nearby burn centers and identify gaps in burn treatment support. Specifically, determine how many burn beds are available.

Coordination Opportunity

Planners should coordinate with burn treatment experts to understand treatment options and identify necessary resources.

4.1.3. RADIATION INJURIES

Due to both the prompt radiation and potential fallout, there will be many people with some level of external radiation exposure, external contamination, or both. Contamination may be a concern for medical facilities and assembly centers. The vast majority of decontamination will be self-decontamination with instructions disseminated by communications experts. Those people needing medical care should be decontaminated as soon as reasonably possible; however, any immediate lifesaving procedures should be performed before decontamination. Chapter 5 provides guidance for people who may have been exposed or contaminated but do not need immediate medical attention. The discussion below focuses on those needing immediate medical attention. Note, however, that the symptoms of ARS are non-specific and triage may be difficult as the symptoms of radiation injury, such as nausea and vomiting, may occur without exposure. The physical location and medical history of triaged populations should be recorded alongside contact information in case follow-up is needed for medical care, biodosimetry, or epidemiological study.

After exposure to radiation, ARS can develop if all the following are true:

- The radiation dose from exposure was high (>0.75 Gy [>75 rad]).
- The radiation was penetrating (i.e., the energy reached internal organs), not just superficial.
- The person's torso, or most of it, received the dose.
- The radiation was received in a short time, usually within minutes, hours, or sometimes days if the dose is high enough.

While all the organs that receive a radiation dose are impacted (hence why radiation injury is a multi-organ injury), there are four classical ARS organ-based subsyndromes that develop additively, based on increasing radiation dose thresholds:

- Hematopoietic subsyndrome (H-ARS, >2 Gy [200 rad], though non-clinical effects can occur as low as 0.75 Gy [75 rad]), caused by radiation injury to the red bone marrow.

- Gastrointestinal subsyndrome (GI-ARS, >5-6 Gy [>500-600 rad]) caused by radiation injury to the intestines.
- Cutaneous subsyndrome (C-ARS, >6 Gy [>600 rad]) caused by radiation injury to the skin.
- Neurovascular subsyndrome (N-ARS, >10 Gy [>1000 rad]) caused by radiation injury to the brain (Military Medical Operations, 2010).

Subsyndromes are multi-system, continuous injuries that are not limited to a dose range, nor are they mutually exclusive. For example, an individual with a 6 Gy (600 rad) external radiation dose may experience both hematopoietic and gastrointestinal (GI) subsyndromes. Similarly, at a dose of 4 Gy (400 rad), treating injury of the GI tract alongside the hematopoietic system can increase the likelihood of recovery. The effects of each subsyndrome are dose-dependent and generally worsen with increased dose and dose rate.

Clinical effects and manifestations of ARS evolve over time in the four successive time phases shown below.

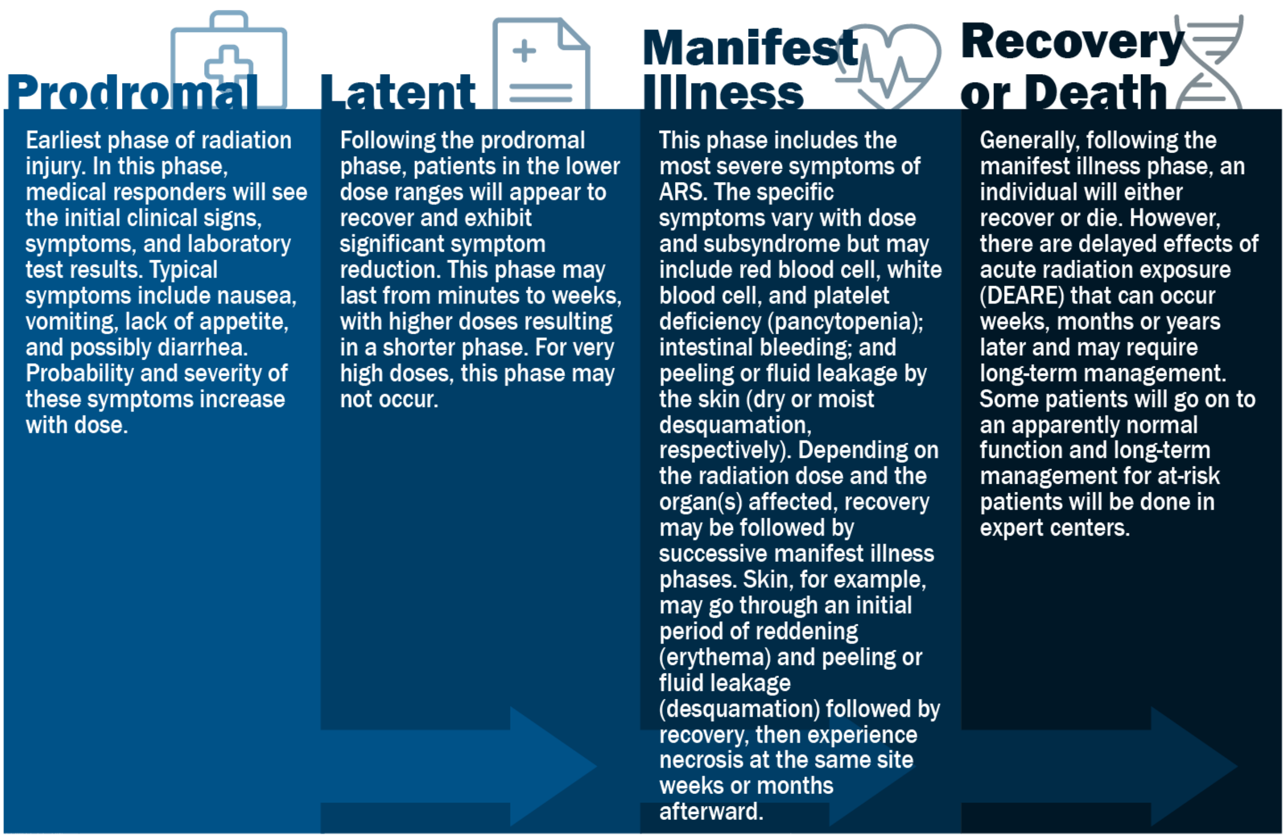


Figure 26: Four Successive ARS Time Phases—Prodromal, Latent, Manifest Illness, and Recovery or Death

Recognizing that whole body exposure produces multi-organ injury, Table 5 below shows whole body radiation dose ranges[30] and effects in smaller dose bands. For more information on the subsyndromes, see the H-ARS section below and discussions of GI-ARS, C-ARS, and N-ARS in Appendix 4.2.

Table 5: Health Effects and Prognosis from Acute, Whole Body Exposures to Different Doses of Radiation (derived from Goans & Waselenko, 2005)

Dose Range, Gy (rad)	Prodromal Phase Severity	Manifestation of Illness	Prognosis (without therapy)
0.5-1.0 (50-100)	Mild	Slight decrease in blood cell counts	Almost certain survival
1.0-2.0 (100-200)	Mild to Moderate	Early signs of bone marrow damage	High probability of survival (>90%)
2.0-3.5 (200-350)	Moderate	Moderate to severe bone marrow damage	Probable survival
3.5-5.5 (350-550) (Often referred to as the LD50)	Severe	Severe bone marrow damage, slight GI damage	Death probable within 3.5-6 weeks (50% of victims)
5.5-7.5 (550-750)	Severe	Pancytopenia and moderate GI damage	Death probable within 2-3 weeks
7.5-10.0 (750-1000)	Severe	Marked GI and bone marrow damage, hypotension	Death probable within 1-2.5 weeks
10.0-20.0 (1000-2000)	Severe	Severe GI damage, pneumonitis (lung tissue inflammation), altered mental status, cognitive dysfunction	Death may occur within hours; certain within 5-12 days
20.0-30.0 (2000-3000)	Severe	Cerebrovascular collapse, fever, shock	Death may occur within hours; certain within 2-5 days

The distinct phases of ARS, as well as the overlapping symptoms from the different subsyndromes, can be seen for several dose ranges in Figure 27. Depending on the dose received, symptoms may not overlap (e.g., 1-2 Gy [100-200 rad], where GI symptoms resolve at about the time that hematopoietic symptoms manifest). At higher doses, symptoms may occur simultaneously. Figure 27

[30] Whole body exposure refers to external exposure of the head, trunk, arms above the elbow, and legs above the knee.

also shows the cyclical nature of some radiation injuries. Following a dose of 3-4 Gy (300-400 rad), GI symptoms manifest then subside after about two days. Two weeks later, however, they reappear.

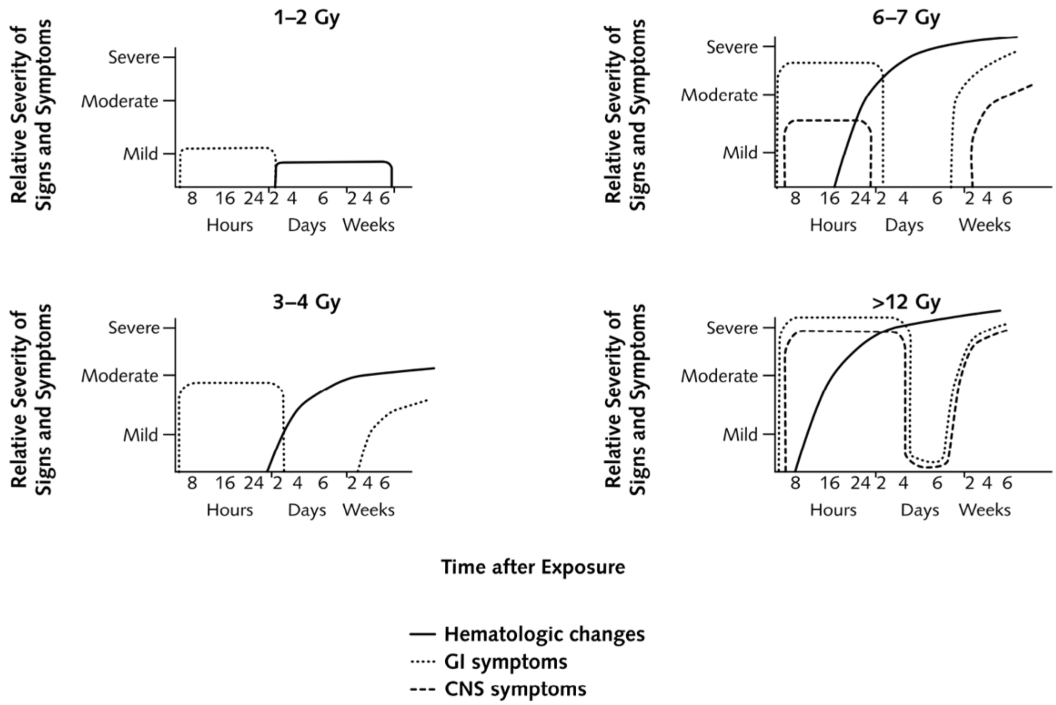


Figure 27: Relative Severity of ARS Symptoms of H-ARS, GI-ARS, and N-ARS Over Time Following Different Doses

Critical to discussions with patients and caregivers when offering assurance or recommendations is to remember that radiation can also produce signs and symptoms months to years later, resulting in DEARE, which is beyond the scope of this document (MacVittie & Farese, 2020; MacVittie & Farese, 2019). Regardless, awareness of DEARE and early treatment of those injuries—if possible—can mitigate or prevent the effects before they manifest.

Coordination Opportunity

Planners should coordinate discussions between medical doctors and radiation injury treatment experts to help ensure healthcare systems understand how to identify and treat ARS and, as treatments develop, also potentially mitigate DEARE in the early stages of a response. Much research is ongoing on the underlying mechanisms of and treatment for ARS and DEARE.

4.1.4. HEMATOPOIETIC ACUTE RADIATION SYNDROME PROPHYLAXIS AND MANAGEMENT

Although all the subsyndromes of ARS are important, H-ARS is particularly significant for the medical response because it occurs at the lowest dose and its treatment will be critical to saving lives. H-ARS is potentially lethal at the lower doses at which it occurs (>2 Gy [200 rad]), meaning that treating it will be critical to saving lives. Even for people with much higher doses, the effects of H-ARS exacerbate the effects of other ARS subsyndromes, making treatment of H-ARS a priority. H-ARS results from damage to the hematopoietic stem cells[31] in the bone marrow and blood cells in circulation. Severity of H-ARS and time of onset vary based on dose, dose rate, host factors, etc. H-ARS affects granulocytes, lymphocytes, platelets, and red blood cells.

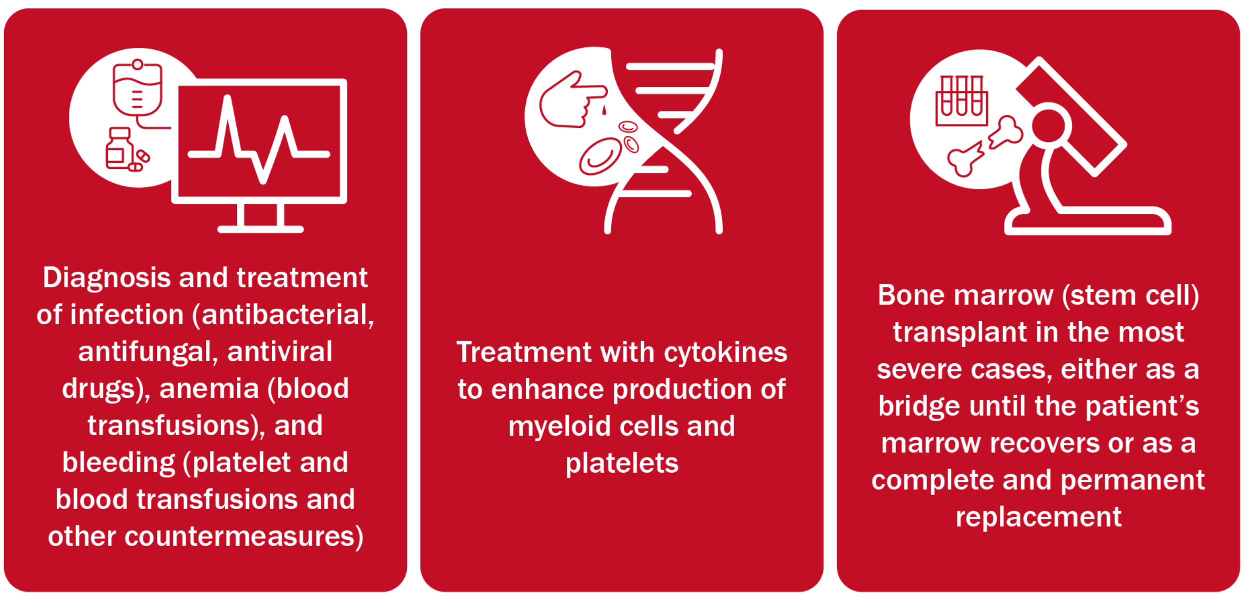


Figure 28: H-ARS Problems and Treatments

Following a nuclear detonation, there will be severe pressure on blood banking systems and a national need to engage the limited number of specialists in hematology/oncology. The Radiation Injury Treatment Network (RITN) is a federally financed, U.S. organization of such specialists.

White blood cell and platelet cytokines are medical countermeasures (MCMs) that can significantly lessen morbidity and mortality in H-ARS patients by increasing the levels of diminished blood elements. Generally, existing US medical response plans recommend cytokine treatment for victims of nuclear detonation who received 2 Gy (200 rad) or more whole-body dose from exposure to radiation, unless those patients are triaged to the Expectant category.

As of 2021, there are three Food and Drug Administration (FDA)-approved white blood cell cytokines for treating H-ARS symptoms: Leukine, Neulasta, and Neupogen. NPlate, a cytokine approved in

[31] Stem cells that produce all of the blood cells, including white and red blood cells as well as platelets, among others.

2008 for certain platelet disorders, was approved by the FDA in 2021 for depletion of platelets caused by radiation injury (DiCarlo et al., 2019).

Some cytokines can be self-administered while others require a nurse or other medical staff to administer. Cytokines are stocked in the Strategic National Stockpile (SNS), but additional doses may be available in user-managed inventories (UMIs) around the country. Planners should understand how to access supplies from both sources. As cytokines will likely be in short supply, at least initially, equitable and effective systems must be used to prioritize patients for cytokine administration until adequate resources arrive.

Coordination Opportunity

Planners should coordinate with medical professionals to determine what cytokines are available and understand or develop plans for regional cooperation given that much of the infrastructure outside the damage zones will be intact. Regional coordination will extend to the wide range of medical supplies. Experience from COVID-19 is relevant to planning for large-scale catastrophic incidents.

H-ARS can also be treated with bone marrow transplants (infusions of hematopoietic stem cells), but they are complex, resource intensive, and expensive (Hick & Weinstock, 2011).

Many of the algorithms and laboratory test systems that have been developed for diagnosing, triaging, and treating H-ARS require information about the total dose from radiation exposure received by each victim (Sullivan J. M., 2013). Dose assessments will help determine decisions about triage, transport, use of countermeasures, and whether in- or outpatient management is required. Planners should be well informed about the kinds of data that can be used for dose estimation. Some tools are available quickly, and some take days to acquire, process, and report. Tests and algorithms used for early triage must provide results very quickly. Frequently used options are listed below.

- Geographic dosimetry: noting where a person was located over time on the official dose maps created for the incident by IMAAC as discussed in Chapter 2.
- Time to vomiting: vomiting onset time after exposure can indicate radiation dose received, with higher doses causing earlier vomiting onset; however, many other factors besides radiation can induce vomiting.
- Lymphocyte depletion kinetics: faster drop in absolute lymphocyte count (from complete blood count [CBC] with differential) is associated with a higher dose from exposure.
- Dicentric chromosome analysis: the greater the dose, the more chromosome damage will be observed. This test usually requires days to complete.

- Other techniques are currently available, and more are under development. This is a category of tests called biodosimetry. Biodosimetry assays the blood and/or tissue and provides a number in Gy that represents the dose received as determined by the biological test. The unit of biodose is Gy, the same unit as the physical dose. To avoid confusion, we use the term biodose for the result of the biodosimetry assay.

REMM and the REMM mobile app can estimate dose based on time to vomiting and/or absolute lymphocyte count.

Refer To

REMM, a great resource for relevant medical information: www.remm.hhs.gov

4.1.5. MICROBIAL INFECTIONS

The risk of microbial infection is widely known to be exacerbated by mechanical trauma or physical burns, but radiation exposure can also greatly increase susceptibility to microbial infection. Patients who develop the hematopoietic subsyndrome of ARS will have severely weakened immune systems and may also develop microbial infections independent of any other injuries. Injury to the GI tract at doses below the GI syndrome can weaken barriers, allowing intestinal organisms to enter the circulation. To combat these infections, planners should expect the medical response to need large quantities of antimicrobials. Various antimicrobials are available as part of standard hospital and pharmacy supplies, and some are stocked in the SNS. Planners should coordinate with local medical professionals to create a plan to acquire and distribute antimicrobials from the SNS.

Action Item

Ensure that response plans include approaches to receive antibiotics from the SNS and to distribute them to points of care. Local arrangements among healthcare facilities can also be a more immediate source of medical supplies to point-of-care facilities referred to as user-managed inventories (UMIs).

Coordination Opportunity

Planners should coordinate with medical professionals to determine what antimicrobial resources are available and form plans for regional cooperation, given that much of the infrastructure outside the damage zones will be intact. Regional coordination will extend to the wide range of medical supplies. Experience from COVID-19 is relevant to planning for large-scale catastrophic incidents.

4.1.6. PSYCHOSOCIAL AND BEHAVIORAL HEALTHCARE

Following a nuclear detonation, psychosocial and behavioral health impacts will be widely prevalent. Issues include anxiety, post-traumatic stress disorder (PTSD), fear, depression, psychological distress, and suicidal ideation. Typically, after large-scale disasters, many of the initial signs and symptoms of mental and psychological distress resolve between a few days and several weeks, but lingering health effects can last for years or decades following a disaster. A nuclear detonation will be a stressor on the mental and behavioral wellbeing of the affected population, community, and nation for months or more, delaying symptom improvement and resolution (Dodgen et al., 2011). Evacuation or relocation, for example, may worsen symptoms or cause additional health issues. Psychosocial and behavioral health issues may not be limited to people directly affected by the disaster and may include people who observed the detonation, lost family members, or were otherwise affected.

Planners must coordinate with behavioral healthcare providers and determine what resources are necessary and how they can be distributed effectively. Additionally, planners should work with behavioral healthcare providers to determine how responders can be trained to administer behavioral health first aid, addressing both responder distress and how to interact with distressed individuals.

Coordination Opportunity

Planners and emergency managers must coordinate with behavioral health community partners (BHCPs) to mitigate and prepare for situationally appropriate behavioral stress, psychiatric disorder development, and exacerbation of existing conditions that might worsen in the resource-stress environment.

Refer To

Disaster Planning Handbook for Behavioral Health Service Programs: store.samhsa.gov/product/tap-34-disaster-planning-handbook-for-behavioral-health-service-programs/pep21-02-01-001

4.2. Initial Mass Casualty Triage in Scarce Resource Environments

The goal of any triage system is to save as many lives as possible by optimizing use of available resources. During normal operations, triage systems prioritize the most severe and time-sensitive injuries. When resources become scarce, however, modifying standard medical practices and protocols for triage and treatment is necessary to save lives.

4.2.1. RESOURCE SCARCITY

Plans for mass medical care in periods of resource scarcity should be understood across all levels of the medical system, particularly how and what changes would be authorized.

Prevailing medical standards of care and triage systems will depend on resource availability, which will change over time. Nomenclature for standards of care varies across jurisdictions, but usually specifies three groups: conventional, contingency, and crisis. Nomenclature for resource adequacy also varies but usually specifies normal, good, fair, and poor. Medical facilities closest to the damage zones are likely to have resource shortfalls. Planners can support such facilities by helping develop appropriate triage and standards for radiation and combined injuries and ensuring these are shared with responder organizations.

Devolving into crisis standards of care with some potentially treatable patients relegated to comfort care can produce enormous stress on responders, healthcare workers, and the medical system. Planning for this requires broad community involvement and, to the extent possible, predetermined indicators, triggers, and strategies.

Refer To

REMM's Standards of Care: remm.hhs.gov/stdsofcare.htm

Indicators and Triggers for Potential Movement to Crisis Care: www.chestnet.org/resources/indicators-and-triggers-for-potential-movement-to-crisis-care

Medical Consequences of Radiological and Nuclear Weapons, Chapter 3: Triage and Treatment of Radiation and Combined-Injury Mass Casualties: www.ncf-net.org/radiation/MedicalConsequencesOfNuclearWarfare3.pdf

COVID-19 Crisis Standards of Care Resources: asprtracie.hhs.gov/technical-resources/112/covid-19-crisis-standards-of-care-resources/99

Action Item

- Identify a specific triage system in planning documents and disperse to responder organizations.
- Consider holding training or exercise sessions that use the selected triage system.
- Ensure that your locality has a plan to implement crisis standards of care.

4.2.2. TRIAGE

As background for how scarce resource environments, radiation injuries, and combined injuries change normal triage systems, planners should understand the trauma triage systems used routinely in their area under normal circumstances, when adequate resources (supplies, staff, space) are available to first responders, first receivers, and hospital systems. Examples of commonly used trauma triage systems include Simple Triage and Rapid Treatment (START); JumpSTART (for pediatric patients); Sort, Assess, Lifesaving Interventions, Treatment/Transport (SALT); and Department of Defense's (DoDs) Delayed, Immediate, Minimal, and Expectant (DIME). Some of these triage methods, however, don't consider radiation injury.

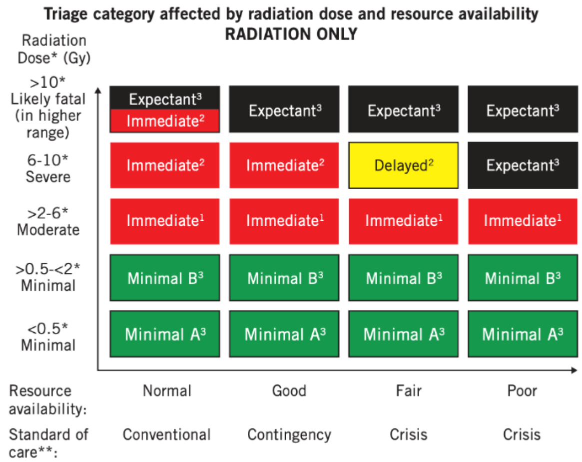
There are many systems for radiation triage, each with a slight variation. The Exposure and Symptom Tool (EAST) is an example of a simpler radiation-only triage tool. It is intended for use in the field *prior to* triage by medical personnel who will use more sophisticated data-driven triage. Incident leaders and planners should engage with medical system leaders about which triage systems are most appropriate for their facilities. These discussions should include questions such as:

- What kind of changes to the normal, existing triage systems might need to be made after a nuclear detonation?
- Where would changes be made—at what venues in the field and in hospital; at what departments within hospitals?
- Who is authorized to make these changes?
- What triggers would be needed to make these changes?
- When would standards of care revert, and who would make these decisions?

Triage cards are described in depth in Appendix 4.4: Triage. While planners are not expected to perform triage themselves, radiation triage cards exemplify how response varies in a scarce resource environment, which is critical for planners as they allocate resources. As seen in the triage card below for radiation only, patients with radiation doses less than 6 Gy (600 rad) can be triaged as immediate or minimal regardless of resource scarcity. However, for doses above 6 Gy (600 rad), some patients might be triaged as expectant in a scarce (poor) resource environment who would have been triaged as immediate if more resources were available. This change in triage demonstrates the importance of ensuring that healthcare facilities have adequate resources during the aftermath of a nuclear detonation and makes resource management the most critical role for planners and emergency managers.

Critical to triage decisions is re-triage as the resource setting changes. A person triaged as expectant might change to immediate with the influx of resources and personnel.

Triage card 1: RADIATION ONLY—triage category affected by radiation dose and resource availability



Legend: Radiation Only

*Radiation dose received by the whole body or a significant portion of the whole body.

**Institute of Medicine. *Guidance for establishing crisis standards of care for use in disaster situations: A letter report.* Washington, DC: Institute of Medicine, National Academies of Science; 2009.

Minimal B: Consider repeating both biodosimetry and clinical reassessments, especially at high end of this dose range

Minimal A: <0.5 Those with physical dose estimates based on location below 0.5 Gy need not report for medical evaluation. Joining a registry may be suggested after the incident.

The purple/black split triage category for >10 Gy indicates that some victims may receive aggressive treatment at discretion of physician, especially if 10 Gy is received over prolonged time period.

Resource availability below NORMAL:

GOOD conditions allow for maintenance of "functionally-equivalent" care through contingency operations

FAIR conditions require delaying care for severe injuries after moderate injuries

POOR conditions require classifying severe injuries as expectant

Myeloid cytokine category	G-CSF recommendation
1	G-CSF indicated.
2	G-CSF indicated, lower priority than Category 1.
3	G-CSF not indicated.

Figure 29: Triage Card 1

4.2.3. MEDICAL COUNTERMEASURES (MCMS) IN THE STRATEGIC NATIONAL STOCKPILE (SNS)

To address resource scarcity in national emergencies, planners should know how to access supplies available via local/regional mutual aid agreements. In addition to local/regional aid, planners should anticipate leveraging the SNS— a federal cache of MCMs and supplies that can be accessed and deployed for large public health disasters. The SNS contains resources for treating injuries specific to nuclear detonations, such as myeloid cytokines for hematopoietic injury from ARS. Additionally, the SNS contains a variety of antimicrobials; burn and blast kits; countermeasures for nausea, vomiting, diarrhea, and pain management; supplies to treat mechanical injury; and supplies to treat fluid loss.

Some MCMs in development have received emergency use authorization (EUA), including cytokine therapies (G-CSF). However, they may be in short supply compared to supportive and palliative therapies.

To deploy SNS assets, SLTT officials make requests through their HHS regional emergency coordinators (RECs). Some resources can be delivered within 12 hours to pre-selected receipt, storage, and staging sites.

Refer To

The SNS website: www.phe.gov/about/sns/Pages/default.aspx

Action Item

- Plans should incorporate assumptions that federal supply delivery will be slowed, due to infrastructure damage. Assume federal resources will not be available for at least 24 hours.
- Develop a plan for countermeasure delivery, storage, and security procedures. This may involve local, regional, and statewide preplanned systematic approaches.
- Develop plans to distribute scarce MCMs, including who is responsible for relevant decisions, such as where to push SNS resources during response.

4.3. The Radiation Triage, Treatment and Transport System (RTR) and Other Medical Response Venues

Following a nuclear detonation, patients in need of medical care will be found miles away, in all directions, from the detonation. Due to infrastructure damage and the number of casualties, typical methods for patient transportation may be unavailable. To address this challenge, the RTR system was developed by an interagency medical response–planning group to organize necessary medical care and resources at strategic locations near the incident. RTR is similar to planning for any emergency incident but specifically accounts for the presence of ambient radiation with the limits it imposes on time spent in a specific location. RTR involves both ad hoc self-organizing locations (RTR 1-3) and pre-determined locations (assembly centers, medical centers, evacuation and transport centers, and expert medical care facilities on a regional and national level). These are utilized in real time based on GIS location using systems such as GeoHEALTH. The RTR systematic approach is intended to characterize injuries while simultaneously organizing and efficiently deploying appropriate material and personnel assets to stabilize and treat victims. RTR sites will be operated by a combination of emergency medical technicians (EMTs) and volunteers. Volunteers will likely include HHS Emergency System for Advance Registration of Volunteer Health Professionals (ESAR-VHP) and ad hoc volunteer health professionals at the time of the incident. If resources (such as point-of-care dosimetry) are available, RTR sites may be able to effectively triage radiation, traumatic, and thermal burn injuries and administer cytokines.

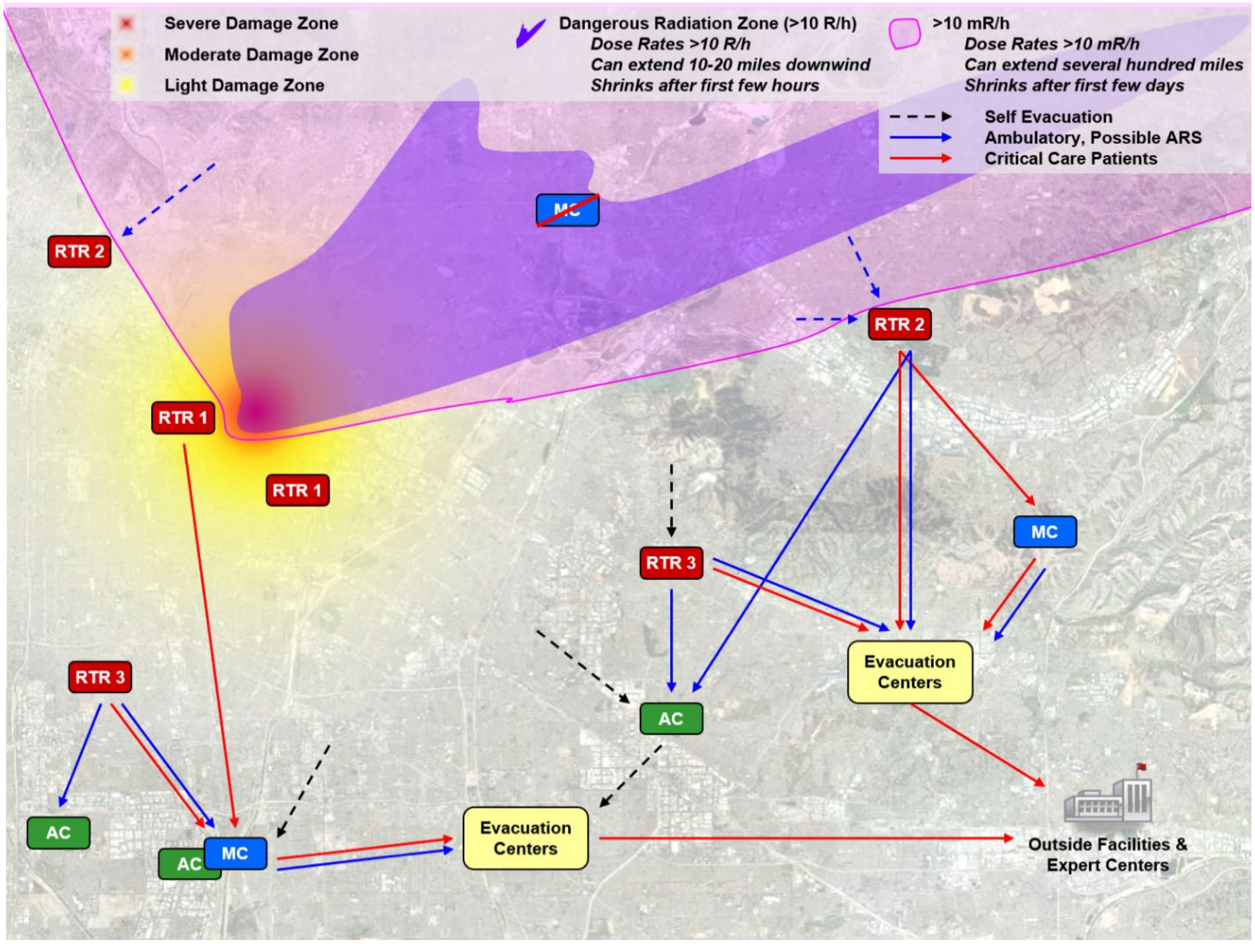


Figure 30: An example layout of the RTR system and various sites involved, including self-evacuation, ambulatory, and critical care routes and relationships. Arrows show likely movement of self-evacuees who are then triaged as *critical care patients* in red or *ambulatory but with possible acute radiation syndrome (ARS)* in blue.

The RTR System is shown in the diagram above, depicting potential locations and interactions of physical damage zones, radiation fallout zones, and the medical response venues in relation to a notional nuclear detonation site. The RTR system is composed of four types of sites—RTR sites, assembly centers (ACs), medical centers (MCs),and evacuation centers (ECs)—each serving a distinct function. The RTR 1-3 sites will likely form spontaneously during an incident. Planners can select other medical sites in advance. RTR 3 sites may be at designated assembly centers (ACs), depending on location and infrastructure.

Action Item

Establish a GIS-based approach for use for emergency incidents. This is applicable to emergencies in general. RTR accounts for the presence of radiation.

Ensure emergency messaging includes directions or instructions for ambulatory victims to transport themselves to ECs or MCs.

Refer To

The "RTR" Medical Response System for Nuclear and Radiological Mass-Casualty Incidents: A Functional TRiage-TReatment TRansport Medical Response Model: pubmed.ncbi.nlm.nih.gov/19618351

4.3.1. RTR 1: LOCATED WHERE THERE IS BOTH PHYSICAL DAMAGE AND RADIATION; RESPONDER TIME LIMITED AND MONITORED.

RTR 1 sites are ad hoc triage and initial treatment sites in the MDZs or LDZs, where fallout might overlay physically damaged sites; these sites serve to stabilize patients and route casualties toward appropriate medical care or other centers. Local emergency medical services (EMS) personnel and volunteers will likely operate RTR 1 sites only after the radiation hazard subsides, setting up the site where they encounter groups of evacuating or self-evacuating populations. To protect responders, radiation monitoring and predetermined exposure limits are essential at RTR 1 sites. RTR 1 site casualties will likely include thermal burns, fractures, lacerations, bleeding, radiation, and combined injuries. Treatment activities include traumatic injury stabilization, initial burn coverage, and trauma and radiation victim triage.

4.3.2. RTR 2: LOCATED WHERE THERE IS RADIATION FALLOUT AND LIMITED PHYSICAL INJURIES; RESPONDER TIME MUST BE MONITORED AND RECORDED TO MINIMIZE EXPOSURE.

RTR 2 sites are possibly within and on the edge of fallout zones, where people self-congregate. Radiation in the environment will be present and, to ensure responder safety, local radiation levels must be monitored to determine how long responders are permitted to work safely. At these sites, local EMS and volunteers perform initial triage assessments and stabilization, then route people to MCs, ACs, or home to self-decontaminate. With the rapid decline in radiation from fallout, it is important to make decisions based on up-to-date measurements.

4.3.3. RTR 3: LOCATED IN AREAS WITH LITTLE TO NO RADIATION AND/OR PHYSICAL DAMAGE.

RTR 3 sites are outside damage and radiation zones, likely operated by local EMS and volunteers. Expected casualties at RTR 3 sites are limited but may include those with radiation exposure, thermal burns, and mechanical trauma. Since these sites are outside the damage zones, injuries at these sites are expected to be relatively minor but may include self-evacuees with more serious injuries or individuals who were severely injured outside the damage zones (e.g., in car accidents caused by flash blindness). Operators will provide stabilization and radiation triage before routing patients to MCs, ECs, or home. Some RTR3s may become ACs.

4.3.4. MEDICAL CENTERS (MCS)

MCs triage people, stabilize patients, or provide necessary interventions before discharging or routing patients to outside expert facilities or ECs. MCs will be in the surrounding local area, upwind of initial fallout plume, and will include hospitals, urgent care centers, field hospitals, and other medical or healthcare facilities nearby. MC staff will likely be healthcare professionals, EMS staff, volunteers, non-governmental organizations (NGOs), and federal support personnel. The Federal Medical System (FMS) is designed to set up field hospitals that could serve as MCs. Planners should familiarize themselves with FMS and other NGOs that could provide support if requested. Expected injuries are in all categories (trauma, thermal burns, radiation, and combined) and will range in severity. Major medical intervention, such as surgery and transfusion, will be available at these sites. Gross decontamination may be performed, preferably outside the MC. There may be infrastructure damage near these sites, but transportation to ECs or expert centers—medical facilities with specific medical expertise, such as burn care centers—may be possible. Myeloid cytokines may be administered at MCs.

4.3.5. ASSEMBLY CENTERS (ACS)

Most ACs will be at predetermined sites, but some will form spontaneously. ACs perform ad hoc screening and gross decontamination (as discussed in Chapter 5) as well as basic medical care, stabilization, and triage. Community Reception Centers (CRCs) and ACs are equipped to perform technical assessments of radiation dose exposure, though CRCs are designed to provide more detailed radiation monitoring, dose assessment, and registration for follow-up (see Chapter 5 for more CRC information). ACs will contain people displaced by infrastructure loss. In addition to local EMS and volunteers, NGOs may be AC operators. If resources are available, myeloid cytokines may be administered at ACs.

4.3.6. EVACUATION CENTERS (ECS)

As patients are screened, triaged, decontaminated, and stabilized, they will be transitioned to ECs, where they will be transported to complete care sites, expert radiation centers, CRCs, or mass care shelters farther from the affected areas. All types of injuries can be expected here. Decontamination before transport may be necessary. Myeloid cytokines may be administered, or re-administered, depending on patient arrival and wait times.

4.3.7. EXPERT CENTERS

After initial radiation screening and stabilization at RTR sites and MCs, patients with severe thermal or radiation burns or who are at risk for severe ARS will transition to expert centers. Burn casualties require specialized expert care and may be transferred to specialized burn centers, though the total number of burn beds nationwide is extremely limited. For radiation injury expertise, clinicians should consult the RITN. Some RITN centers may be equipped to handle burn and major trauma injuries. Trauma centers will also care for victims. As the hematopoietic subsyndrome of ARS can develop days to weeks after initial exposure, some patients may be managed as outpatients until they develop severe illness. Telemedicine may be necessary to leverage both burn and ARS expertise as well as other specialized assets for the large surge in patients.

Coordination Opportunity

- Local and regional planners should coordinate with RITN facilities when developing nuclear detonation response plans.
- Coordinate with the American Burn Association to identify burn centers and best practices regarding mass casualty burn incidents.

Refer To

- The RITN, is a consortium of U.S. medical specialists with expertise and plans for implementing care during major emergencies. Telemedicine consultation with RITN may also be implemented during emergencies with large numbers of patients. ritn.net/treatment
- The American Burn Association is also an expert referral center for burn patients. Telemedicine consults may be available. ameriburn.org/public-resources/find-a-burn-center

4.4. Fatality Management

Following a nuclear detonation, the large number of fatalities will overwhelm medical examiners/coroners (ME/Cs). Many victims may never be found or identified. A respectful, culturally sensitive plan for fatality management will directly impact public perception of the government's emergency management abilities and the community's ability to recover. This document focuses on early response, when lifesaving operations will take precedence over fatality management, but with time, fatality management will have increasing importance.

After a nuclear detonation, the need for fatality management will likely exceed anything experienced in past disasters. Fatality management includes recovery, identification, storage, final disposition, notification of next of kin, and death certificates.

Coordination Opportunity

Coordinate with communications experts to consider creating a dedicated phone line or websitespecifically for collecting fatality information.

4.4.1. HANDLING CONTAMINATED REMAINS

In the immediate aftermath of a nuclear detonation, a small minority of the fatalities handled by ME/Cs will be contaminated. Most of these fatalities will be victims who evacuated and died because of traumatic or thermal injuries. As a result, many of them will have been decontaminated during evacuation or medical treatment. As the response unfolds and remains are recovered from the damage zones, the probability that remains are contaminated increases. Complete external decontamination may not be possible for all decedents, and internal decontamination is not necessary or possible. Decontamination should follow any victim identification, forensic, or medicolegal[32] work. Planners should coordinate with radiation experts to understand the risks of handling contaminated remains and develop effective protective measures for responders.

Coordination Opportunity

Coordinate with radiation experts and health physicists to understand the risks of handling contaminated remains and develop plans to protect responders and ME/Cs.

From a planning perspective, handling contaminated remains is very similar to screening and decontaminating living people. Responders and ME/Cs responsible for receiving and processing decedents should have access to radiation detectors to survey remains; appropriate dosimetry; and either soap and water or an appropriate dry decontamination method (e.g., vacuums with HEPA filters). Radiation contamination control methods should be included in plans to prevent the spread of radiation and reduce dose to ME/Cs working to process fatalities. Generally, following decontamination, no special container or transport method will be required for contaminated remains. If remains still exceed contamination limits following decontamination, temporary internment or storage at the site may be necessary.

The final resting place for contaminated remains should be considered carefully during planning. Lead coffins are generally not recommended as they pose an additional environmental hazard due to leeching heavy metals. Cement coffins are a better alternative, serving the same purpose without the environmental risks. Similarly, cremation is not generally recommended due to the potential

[32] Of or relating to both medicine and law.

concentration of remaining radionuclides and the potential for contamination of the cremation facility.

As with all fatality management, care should be taken in planning to ensure respect for the remains is maintained throughout the process. Handling of contaminated remains still requires planners to accommodate the social, cultural, and religious considerations of the deceased and their families to the maximum extent possible.

Refer To

CDC *Guidelines for Handling Decedents Contaminated with Radioactive Materials:* www.cdc.gov/nceh/radiation/emergencies/pdf/radiation-decedent-guidelines.pdf

An updated version of this document is expected in 2022.

Action Item

Develop effective protective measures for emergency workers handling contaminated remains, such as ME/Cs.

4.4.2. FATALITY MANAGEMENT RESOURCE SHARING

SLTT entities have limited fatality management capabilities and will quickly exhaust their resources, requiring additional assistance. Even federal mortuary capabilities are limited. It may be necessary to lower public expectations and use nontraditional disposition techniques (e.g., temporary interment).

Additionally, planners should work with neighboring states and jurisdictions to facilitate fatality management resource sharing. In particular, interstate coordination must be planned in advance, because state legislation may impede fatality transportation and other mortuary services across state lines.

Coordination Opportunity

Coordinate with surrounding states to address legal constraints of fatality management, movement, and tracking.

4.4.3. FATALITY MANAGEMENT PLANNING CONSIDERATIONS

Before developing fatality management guidance, planners must develop a thorough understanding of their community's relevant cultural practices, so they can respectfully integrate them into plans.

With that in mind, to prepare for fatality management following a nuclear detonation, SLTT planners should:

1. Designate a proper medical/legal authority to lead the fatality management operations.
2. Identify available fatality management capabilities in their jurisdiction (e.g., personnel, equipment, and supplies).
3. Create a comprehensive, incident-specific plan for managing contaminated decedents, including procedures for gathering, recovering, transporting, storing, and disposing of remains.
4. Develop a comprehensive health and safety plan to protect those handling decedents, including personal monitoring devices (described in Chapter 2 and Appendix 2.1).
5. Develop guidelines for conducting notification or disposition meetings with next of kin and keeping next of kin apprised of identification activities.
6. Develop guidelines for gathering fatality information data, such as collecting family reference DNA.
7. Consider potential cross-contamination hazards when developing fatality management plans.
8. Anticipate requesting mortuary assistance from outside the impacted area.
9. Create public messages regarding how decedents will be handled and develop a plan for handling public concerns or requests.
10. There will likely be insufficient resources to make any special consideration when handling animal carcasses, including pets. However, plans should consider tag recovery or a registry of information.

There are many references and resources available to support planners with fatality management—to access these resources, visit Appendix 4.7: Resources for Medical Examiners and Coroners (ME/Cs) and Fatality Management Planning and Appendix 4.6: Response Support Teams and Planning Resources.

5. Population Monitoring

The recommendations in this chapter are derived from HHS CDC publication *Population Monitoring in Radiation Emergencies: A Guide for State and Local Public Health Planners* and *A Guide to Operating Public Shelters in a Radiation Emergency*.

Refer To

- *Population Monitoring in Radiation Emergencies: A Guide for State and Local Public Health Planners:* www.cdc.gov/nceh/radiation/emergencies/pdf/population-monitoring-guide.pdf
- A *Guide to Operating Public Shelters in a Radiation Emergency:* www.cdc.gov/nceh/radiation/emergencies/pdf/operating-public-shelters.pdf

Population monitoring describes the overall process of helping the impacted population by assessing their potential for exposure to radiation or contamination through interview and screening with equipment (if available). The process also includes follow-on actions such as referral for medical evaluation or treatment, decontamination, and establishing a registry to help monitor for potential long-term health effects.

Population monitoring begins soon after a nuclear/radiological incident and continues until all potentially affected people have been monitored and evaluated for the following:

1. Necessary referral for medical treatment
2. Radioactive contamination on the body or clothing (external contamination)
3. Intake of radioactive materials (internal contamination)
4. Removal of contamination (decontamination)
5. Radiation dose received and resulting health risks
6. Assessment of long-term health effects

The first five elements listed above should be accomplished as soon as practical, though some facilities may only be able to carry out the first two. These first two are the most critical and can take place at an ad hoc screening, CRC, or mass care shelter location. These facilities are defined below.

Elements three and four will likely occur at CRCs or mass care shelters with radiation detection capabilities. Although assessment of internal contamination (i.e., quantification of intake rather than presence of internal contamination) would not occur at a CRC or mass care shelter, these facilities may identify people with potential for internal contamination. If equipped, CRCs and mass care shelters may collect urine samples to assess likelihood of internal contamination.

Elements five and six will be determined jointly by public health and radiation control staff, likely located outside of the aforementioned facilities. The results would be communicated to the individuals through their health departments. Long-term health effects will be assessed with a population registry and epidemiologic investigation that will likely span several decades. Those activities are beyond the scope of this guidance.

Figure 31 displays possible ad hoc, CRC, and mass care shelter locations relative to the incident site. Many of the activities at these three locations will be similar.

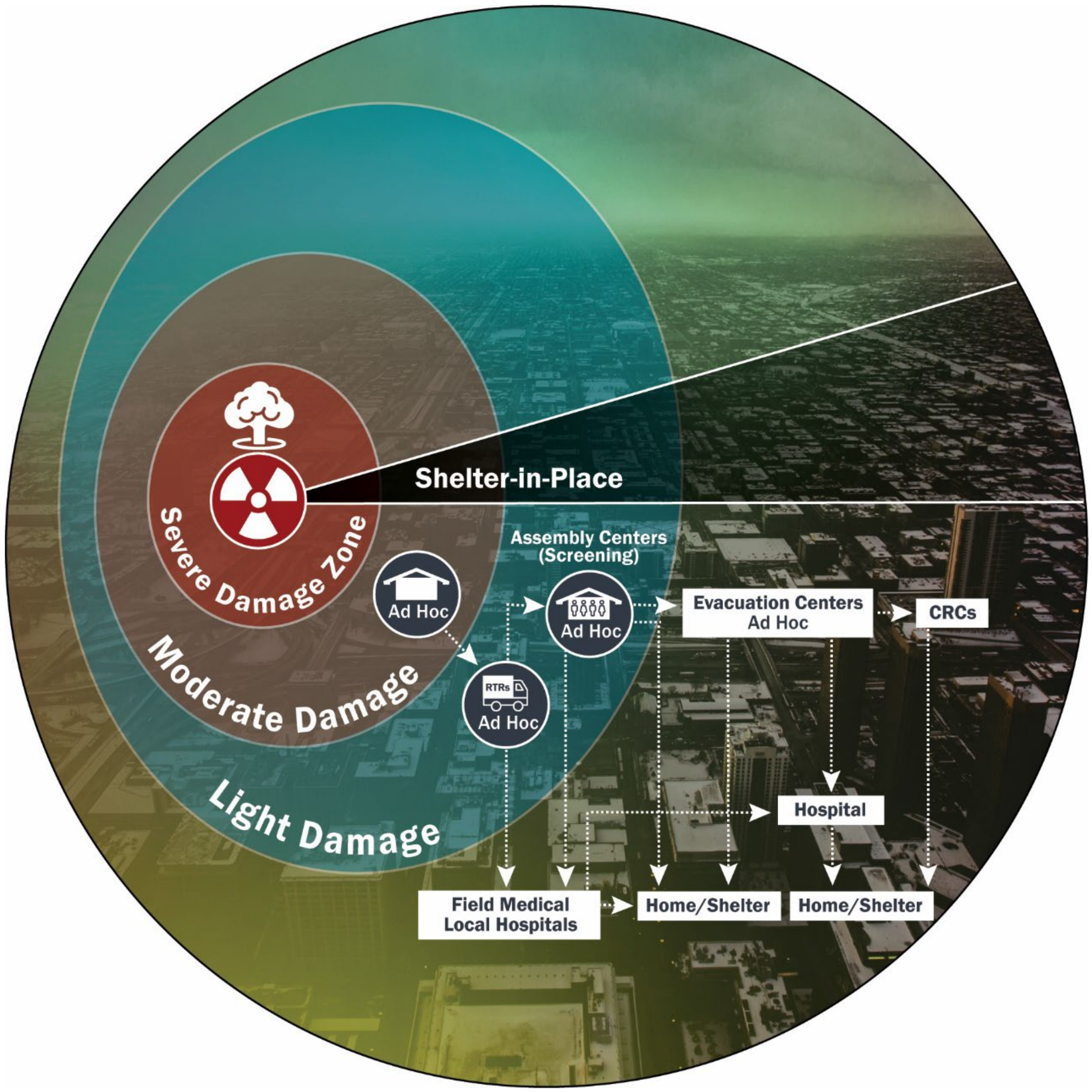


Figure 31: Example of ad hoc screening, CRCs, and mass care shelter screening locations relative to the incident site. Site roles and movement from one site to another are described throughout Chapter 5.

Elements of population monitoring may be performed at various facilities:

Ad hoc screening location: Occurs near the incident site as people leave the affected area. The purpose of ad hoc screening is to quickly identify highly contaminated individuals who need to be decontaminated promptly to avoid accruing a large dose. Ad hoc screening will be performed once local authorities determine it is safe for people to start evacuating the area. Ad hoc contamination screening may take place at or near stand-alone locations or collocated with ACs, ECs, RTRs, or other locations set for that purpose. Ad hoc screening does not replace the more detailed/deliberate screening at CRCs.

CRCs: CRCs are designed to screen, decontaminate, and register people, and will be located outside the impacted area. CRCs also address the needs of displaced populations and concerned citizens hundreds of miles from the blast; their needs differ from those of the victims near the detonation. CRCs can also identify individuals subjected to higher exposure and refer them to appropriate medical care or follow-up. While CRCs and ACs can be collocated and perform some of the same functions (such as ad hoc screening and gross decontamination, basic medical care, stabilization, and triage), ACs will be located closer to the impacted area and would not be set up to provide detailed radiation monitoring, decontamination, dose assessment, and registration for future follow-up. Regardless of location or proximity to the impacted area, when the term “population monitoring” is used in this guide, it is assumed to be describing an activity taking place at a CRC or mass care shelter.

Mass care shelter screening: Mass care shelter screening occurs at mass care shelters set up outside the impacted area that are close to CRCs. Ideally, individuals will arrive at mass care shelters after decontamination/screening at an ad hoc location or CRC. However, mass care shelters may receive individuals who have not been decontaminated/screened.

The *CDC Population Monitoring Guide* does not explicitly use a graded system for staffing and resourcing at CRCs. A subsequent CDC guidance document, *A Guide to Operating Public Shelters in a Radiation Emergency* describes a graded system for mass care shelters based on the availability of radiation detection resources. This graded approach can be extended to ad hoc and CRC locations.

The graded contamination screening approach includes three capability categories based on complexity or radiation detection capability:

Basic	The minimum capabilities necessary to operate a facility following a radiation incident. Many of the recommendations provided in this chapter are precautionary and address facilities that lack access to radiation detection equipment and trained personnel.
Intermediate	Enhanced radiation detection capabilities and access to trained staff. However, these resources may be in limited supply, and facility operators may need to prioritize these resources.
Advanced	Sufficient access to radiation detection equipment and trained staff to perform all tasks requiring the application of these resources.

Figure 32: Graded Contamination Categories Cased on Complexity or Radiation Detection Capability

Refer To

A Guide to Operating Public Shelters in a Radiation Emergency:
www.cdc.gov/nceh/radiation/emergencies/pdf/operating-public-shelters.pdf

Table 6 summarizes which activities will likely occur at the aforementioned locations.

Table 6: Range of Anticipated Capabilities for Screening, Decontamination, and Dose Assessment by Location

Location	Ad-hoc RTR System	CRC	Mass Care Shelter	Off-site
Referral for Immediate Medical Need	X	X	X	
External Contamination Screening	X	X	X	
Initial Assessment for Internal Contamination		X**	X**	X*
External Decontamination	X (gross decontamination may be done here)	X	X	
Dose Assessment		X***	X***	X*
Risk Assessment for Long-Term Health Effects		X***		X*

Notes:
* Conducted by Radiation Control Program, local health department, or both (not tied to specific location).
** Only for triaging and urine collection when internal contamination is suspected.
*** Not likely in most settings, but some locations may be able to do early estimates of doses based on external exposure when location at time of incident and duration of exposure are known.

This chapter walks through population monitoring considerations and discusses the process of screening and decontamination. Additionally, this chapter includes a discussion of how these processes are applied at CRCs and mass care shelters. Appendix 5.5 includes an expanded discussion of available tools and resources as well as several additional factors for consideration during planning.

5.1. Contamination Considerations

There are several primary considerations when screening for contamination. These are particularly critical for nuclear emergencies because of the high number of casualties. The immediate priority of any contamination screening is to identify individuals whose health is in immediate danger and who require urgent care. Near the incident scene, contamination screening can be accomplished as part of medical triage described in Chapter 4 or at ad hoc settings. Regardless of location, management of serious injury takes precedence over radiological decontamination.

Following a nuclear detonation, the primary considerations for screening are:

- Even without instruments, a few key questions (regarding location and exposure time) can be used to identify people with potentially high exposure or contamination that may require medical follow up.

- If potentially contaminated with fallout, decontamination should be performed as soon as possible. Because of the rapid decay of fallout, most of the exposure hazard from the contamination takes place in the first few minutes and hours after contamination occurs.

- In most cases, external decontamination can be self-performed if straightforward instructions are provided. Promoting self-decontamination can reduce the CRC and mass care shelter workload, because screening self-decontaminated individuals can be expedited.

- Gross external decontamination, such as brushing away dust or removal of outer clothing, should be recommended if contamination is suspected or measured. Gross decontamination should generally be sufficient to prevent acute radiation health effects to the skin or whole body when accomplished soon after the contamination occurs. Cross-contamination[33] concerns are secondary to removing external contamination, especially in a nuclear emergency.

- Contamination screening and decontamination activities should remain flexible and scalable to reflect available resources and competing priorities. For example, contamination screening criteria at an ad hoc location may be less stringent than at a CRC or mass care shelter because its primary purpose is to identify the most contaminated individuals and prioritize their decontamination. In those situations, quick decontamination may involve removal or careful brushing of external clothing, followed by the use of wet wipes or dry decontamination methods for exposed skin. When water is scarce or needed to fight fires, wet wipes or dry methods[34] can be used for decontamination. Regardless of decontamination method, decontaminated people should be screened afterwards to ensure they do not require additional decontamination.

- Radioactive contamination is not immediately life threatening. Decontamination doesn’t take the same priority as other life-threatening hazards or injuries. Since decontamination involves removal of contaminated clothing and washing of exposed body surfaces, it does not require special expertise; individuals who are self-evacuating may be advised to self-decontaminate. Suggestions for monitoring and decontamination in this chapter assume radioactive material is the only contaminant and that there are no chemical or contagious biological agents present.

- Screened and decontaminated populations may need to provide evidence of screening to access or use shelters, hotels, or other services. Certificates or other documentation of screening or decontamination can also help prevent repeated, unnecessary screenings and conserve response resources.

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[33] Cross-contamination, in this context, refers to contaminated individuals exposing others to contamination by contaminating surfaces or coming into contact with others.

[34] Dry decontamination methods, such as wet wipes, do not utilize water, so they are ideal for cold weather or scarce water situations.

What Would You Do?

How do you think your constituents would self-decontaminate if they were not given specific guidance?

Contamination screening can be very resource intensive and requires subject-matter expertise to accomplish effectively. For details about available screening support resources, see Appendix 5.2: Strategies for Screening and Decontaminating People.

For example, stringent contamination screening criteria at ad hoc locations may delay prompt evacuation. Therefore, radiation survey methods, radiation screening criteria, decontamination guidance, and other services should be adjusted to prioritize individuals' needs and resource availability.

Early radioactivity monitoring and decontamination decisions must be made in the context of overall response operations.

Action Item

Ensure plans address a range of available resources and priorities.

5.2. Screening for Contamination

5.2.1. SCREENING FOR EXTERNAL CONTAMINATION

The first step of external contamination screening is to check for radioactive contamination on individuals' bodies, clothing, and shoes. Detailed radiological surveys are not necessary, so initial screenings for external contamination can be done in a matter of seconds by trained professionals using proper radiation detection instruments. Depending on the situation, available staff, and available decontamination resources, screening each person may take longer and more restrictive radiological screening criteria may be used.

What Would You Do?

How would you categorize your radiation detection capabilities to screen large populations for contamination?

External contamination screening may be a very quick process at ad hoc screening locations. The primary goals are to identify the most contaminated individuals and provide self-decontamination instructions. External contamination screening at CRCs may be more deliberate and detailed, depending on available resources and the number of affected individuals. At CRCs, this may range from screening using a portal monitor only to using a portal monitor followed by screening with handheld instrumentation to pinpoint contaminated areas. Screening at a mass care shelter may also be more deliberate and detailed, depending on available resources.

There is no universally accepted level of radioactivity (external or internal) above which a person is considered contaminated and below which a person is considered uncontaminated. A discussion of key considerations in selecting a contamination screening criterion and a number of benchmark screening criteria are provided and referenced in Appendix D of the CDC *Population Monitoring in Radiation Emergencies* guide. Key considerations include instrumentation available (type, number); throughput;[35] next destination (where people are being sent after screening); and time since detonation to account for changes in isotope mix.

Screening levels may be adjusted when large populations require screening in a short time period, especially when resources are limited. Subsequently, state and local planners should consider a range of circumstances and establish operational levels for several circumstances beforehand. Pre-established values can be communicated clearly to emergency response authorities early in the response. It is important to note that different values are used for different purposes, and users are encouraged to work with the radiation control authority in their jurisdiction to pre-determine screening values based on their resources and revise as conditions improve. Ad hoc screening locations should focus on high throughput screening to minimize fallout exposure, especially in the first few hours and days following an incident. The rapid decay of fallout radiation in the first few hours and days of the incident means that a delay in screening/decontamination could result in significant additional dose by victims.

Contamination screening activities and decontamination services offered should remain flexible and scalable to reflect the prioritized needs of individuals and availability of resources at any given time and location.

Action Item

Develop scalable and flexible contamination screening and decontamination plans and policies.

Screening level guidance for CRCs and mass care shelters is available on RadResponder's resource page, though an account is required for access. RadResponder is a free, federally funded service to assist in radiation monitoring, establishing screening points, and supporting long-term follow-up.

[35]The total number of people that can be processed by unit time (hourly, shift, etc.).

Refer To

RadResponder Special Feature Webinar—Population Monitoring and Community Reception Centers: www.youtube.com/watch?v=3TvJAJ2eU2M

What Would You Do?

- How would your screening criteria change farther from the incident?
- What resources (expertise, instrumentation, etc.) do you currently have for screening? How might your operational levels vary if you had more resources? What about fewer resources?

People reporting to CRCs who are not a contamination concern, either due to their point of origin or previous screening, are referred to discharge stations and should avoid being comingled with potentially contaminated people, although families should not be separated. Wrist bands or similar tools can be used to distinguish people who have been screened and cleared through decontamination.

Action Item

Include a method for distinguishing screened individuals from unscreened individuals.

Most people will be able to self-decontaminate at home or at other locations, but there must be provisions for those who cannot, such as those who cannot access showers or sinks. During the decontamination process, a best practice is to determine if caregivers can assist their dependents with washing. Direct those who do not have wounds to self-decontaminate as described in Section 3.3.

What Would You Do?

How might decontamination provisions vary for people with disabilities, functional needs, or access needs?

Use of pumper fire truck systems for mass decontamination, although effective for decontaminating large numbers, is strongly discouraged and not advised when other decontamination methods are available. If water resources are scarce or not available, changing outer clothing and shoes or carefully brushing off fallout dust can significantly reduce exposure. When there are cold temperatures or poor weather conditions, water-based decontamination techniques may be unadvised and local decontamination of exposed skin using sink, wet wipes, etc. may be preferred.

Furthermore, firefighting resources may be more urgently needed to fight fires or conduct search and rescue operations.

What Would You Do?

How would you implement decontamination when water resources are scarce?

To the extent possible, emergency workers should attempt to contain the spread of contamination from runoff or solid waste generated by decontamination activities. However, containment measures should not slow or delay evacuating contaminated individuals. Addressing peoples' needs and facilitating their decontamination or evacuation takes priority.

People in need of medical care must be directed to a medical treatment facility or a designated medical triage station, if established. Response organizations should be prepared to provide security for designated monitoring, decontamination, and staging areas.

5.2.2. SCREENING FOR INTERNAL CONTAMINATION

Internal contamination is radioactive material that has entered the body via ingestion, inhalation, or a wound. Following a nuclear detonation, internal contamination is a minor health concern relative to burn injuries, traumatic injuries, or high external radiation doses from initial radiation exposure or nuclear fallout. However, there is potential for internal contamination and, regardless of relative significance, internal contamination can be a source of anxiety for the public. MCMs for internal contamination only treat a few radionuclides, not all the radionuclides present following a nuclear detonation.

Action Item

Ensure plans prioritize life-threatening or other severe injuries over contamination screening and decontamination.

While not an immediate priority following a nuclear detonation, accurate information about levels of internal contamination is critical for determining when medical intervention is necessary. For some radionuclides, external contamination screening can indicate the extent of internal contamination. Physical location during the incident and external contamination can also indicate the likelihood and degree of internal contamination. Individuals with high levels of contamination above their shoulders are more likely to be internally contaminated, due to inhalation or ingestion of contaminated material. First responders, pregnant individuals, and children should be prioritized for internal contamination screening.

The methods and equipment for assessing internal contamination are more advanced than those required to conduct external monitoring. Specifically, internal contamination screening may require a post-decontamination whole body, lung, or thyroid radioactivity count, and/or laboratory urine analysis and health physics support to interpret results. Collectively, internal contamination monitoring procedures are referred to as "bioassays" or "radiobioassays." Generally, these bioassays require off-site analysis of urine samples by a clinically certified government or commercial laboratory. Although some results will be available quickly, it may be weeks or months before all results are available, depending on the size of the population monitored and the radionuclides involved. Laboratory results can provide definitive contamination information, especially in the case of alpha-emitting radionuclides.

5.2.3. SELF-DECONTAMINATION

For most people, steps to removing or reducing external contamination in the initial hours, perhaps days, will be self-performed. Family members, companions, or caregivers can assist individuals as necessary. Emergency management officials must quickly provide simple and straightforward instructions in languages appropriate for the affected community. As discussed in Chapter 6, communication after a nuclear detonation will be difficult due to loss of infrastructure. Every possible communication outlet should be used to provide lifesaving messages, including instructions for self-decontamination.

For most people, a thorough wash or complete removal of external contamination will not be practical in the early hours or days, but any action to reduce the external contamination should be encouraged. It is important to emphasize the importance of "dusting off"[36] as often as possible until people can change clothes and shoes or wash. In providing instructions for self-decontamination, the use of phrases such as "washing" and "change of clothes" are preferred to "decontamination" because they are easier to understand, provide the same meaning more clearly, and sound less threatening.

Action Item

Ensure decontamination messaging is clear and concise, avoiding jargon.

Another challenge in providing blanket self-decontamination instructions is that peoples' circumstances, supplies, and facilities may vary greatly. For example, some may not have access to water, clean replacement clothing, shoes, or bags to store away contaminated clothing. Examples of instructions include:

[36] Brushing or shaking external clothing to remove contaminated dust.

Figure 33: Examples of Self-Decontamination Instructions

These actions can be performed at any location or at ad hoc screening locations set up by emergency response organizations to facilitate washing. Prior to opening these facilities, planners should ensure that an ample supply of replacement clothing, shoes, plastic bags, and wet wipes are available. First responders can also take these actions to reduce their exposure unless their safety officer provides other specific protocols.[37]

[37] Not likely in most settings, but some locations may be able to do early estimates of doses based on external exposure when location at time of incident and duration of exposure are known.

SAMPLE SELF-DECONTAMINATION INSTRUCTIONS

- ☐ Remove contaminated clothes and shoes and place them in a bag.
- ☐ Wash your body with warm water.
- ☐ Use cloth, sponge, soft brush, etc. to clean skin or clothing.
- ☐ Begin with mild agents, like soap and water.
- ☐ When showering, try to direct rinse water away from face and body. If washing your hair, do not use conditioner.
- ☐ Keep materials out of eyes, nose, mouth, and wounds.
- ☐ Avoid scratching, burning, or causing breaks in the skin.

Coordination Opportunity

Coordinate with safety officers to avoid contradictory protocols.

For more detailed strategies for screening and decontamination, see Appendix 5.2: Strategies for Screening and Decontaminating People. These strategies vary for different populations—to understand how these populations differ, see Appendix 5.1: Impacted Populations.

Additionally, planners must develop strategies to decontaminate animals, cars, buildings, etc. For more details, see Appendix 5.3: Screening and Decontaminating Service Animals and Pets and Appendix 5.4: Handling Contaminated Vehicles.

5.3. CRC and Mass Care Shelter Operations

CRCs and mass care shelters are distinct and complementary operations. CRCs provide population monitoring services, including contamination screening, decontamination, registration, and limited medical evaluation and care. Mass care shelters provide temporary housing, security, food, health and mental health services, ongoing health surveillance, and other similar services.

It is not anticipated that CRCs or mass care shelters would be set up to receive injured individuals. However, plans should include transportation provisions for these facilities to transport victims in need of immediate medical attention to healthcare facilities. The network of CRCs feeds into the larger network of mass care shelters, as illustrated in Figure 34.

Action Item

Ensure plans include provisions to transport injured victims to healthcare facilities.

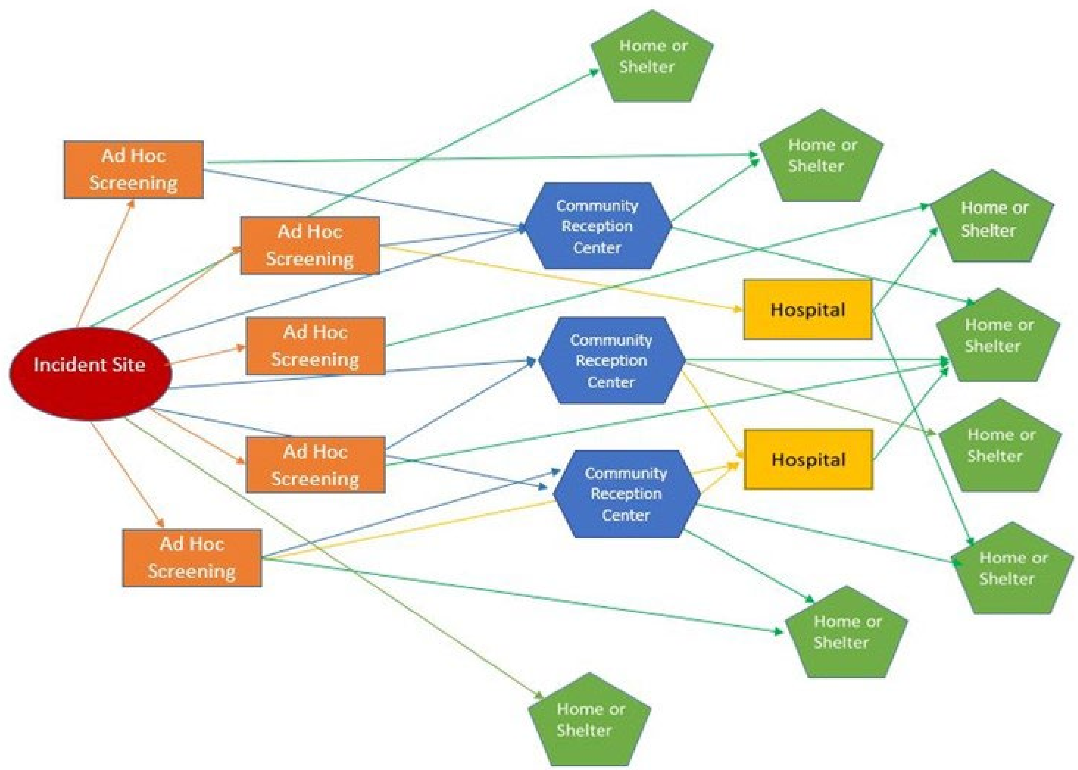


Figure 34: Possible Pathways That People May Follow to Get Screened for Contamination

Ideally, CRCs will process individuals before they report to mass care shelters; however, as shown in Figure 34, mass care shelters may receive people who have not been screened at ad hoc screening locations or at CRCs. Regardless, there are special considerations for operating mass care shelters after a radiation emergency to ensure the health and safety of mass care shelter residents and staff. The aforementioned CDC *A Guide to Operating Public Shelters in a Radiation Emergency* provides additional guidance regarding these considerations for planners, mass care shelter operators, and mass care shelter workers.

Refer To

DHS National Urban Security Technology Laboratory (NUSTL) is currently developing *Nuclear Detonation Response Guidance: Planning for the First 72 Hours,* which includes a graphic with radiation detection, search and extraction/rescue, and decontamination operations, overlaid with damage zones to provide additional context.

State and local authorities must work with ESF-6 (Mass Care, Emergency Assistance, Housing, and Human Services) and the American Red Cross to establish an evacuee tracking system. This system enables prompt location of evacuees, patients, fatalities, survivors, displaced persons, and other victims. Extensive hurricane response experience and tools can be used to achieve this.

State and local agencies should establish a survivor registry and locator databases as early as possible. Initially, the most basic and critical information to collect from each person is his or her name, address, and contact information.

5.3.1. MASS CARE SHELTER CONSIDERATIONS

Jurisdictions should have pre-existing plans and procedures for establishing all-hazards, general population mass care shelters. Neighboring jurisdictions should also have plans to provide mutual aid to impacted jurisdictions, including provisions for mass care shelters for people evacuating the impacted area.

CDC *A Guide to Operating Public Shelters in a Radiation Emergency* recommendations may apply to emergency or temporary mass care shelters in areas withelevated radiation, but these types of mass care shelters are not the guide's focus.The mass care shelters described in the CDC Shelter Guide are long-term mass care shelters in areas where radiation levels are at or near natural background levels.

Many organizations have mass care shelter plans for facilities in their communities. Depending on the nature of the radiation emergency, some of these facilities may not be suitable locations for mass care shelter operations due to utility outages, infrastructure damage, or elevated environmental radiation levels. Mass care shelter operators have standing protocols for managing and overcoming utility outages andinfrastructure damage but may not be equipped or trained to assess environmental radiation levels. Mass care shelters should be established in uncontaminated or low background radiation areas with environmental radiation levels below 1 μSv/h (0.1 mR/hr). In the first 24–48 hours after the incident, emergency managers and radiation control officials are likely to have access to detailed maps identifying radiation control zones, and they can help mass care shelter operators determine if their existing or proposed mass care shelter locations are in low background radiation areas.

What Would You Do?

How would you identifyalternate mass care shelter locations if your previously established locations are not suitable due to their proximity to the impacted areas?

Mass care shelters may be considered short-term operations initially until environmental monitoring activities near the incident site are completed and radiation control zones are established. Mass care sheltersrequire relocation plans in the event they must move to lower background radiation areas. In certain circumstances, CRCs may not be established yet.

Mass care shelters must prepare for residents with disabilities, functional needs, or access needs in accordance with the Americans with Disabilities Act of 1990 (ADA). For examples of how to make mass care shelters more accessible, visit the CDC's Disability and Health Emergency Preparedness page, particularly the section on Resources to Assess Shelters. Planners should also reference Appendix 5.3: Screening and Decontaminating Service Animals and Pets, to develop plans for people arriving with animals.

Refer To

Disability and Health Emergency Preparedness:
www.cdc.gov/ncbddd/disabilityandhealth/emergencypreparedness.html

Key considerations for screening and decontamination at mass care shelters

- In instances of life-threatening or serious injuries, medical care takes priority over contamination screening and decontamination.
- Mass care shelters coordinating with and receiving people from CRCs must incorporate appropriate screening and decontamination into mass care shelter operations, if not already performed at the CRC.
- Mass care shelters may receive people before CRCs are available, necessitating screening people, service animals, pets, personal possessions, and vehicles for radioactive contamination and conducting decontamination, as appropriate.
- Screening criteria should be scalable and flexible to adjust to varying incidents and screening capabilities.
- Decontamination plans should be scalable and flexible to respond to different incidents and available decontamination capabilities.
- Mass care shelter staff working in contamination control zones should be screened for contamination at the end of their shifts and anytime they leave the contamination control zone. Subsequently, they should be decontaminated, if necessary.

What Would You Do?

- How would you modify your shelter operations to allow access to people who have not been screened at a CRC?
- If you were working in a control zone and forgot to be screened for contamination prior to leaving, what would you do?

- How would you accommodate pets that were brought to the shelter? Would they be monitored and decontaminated? For relevant information, reference Appendix 5.3: Screening and Decontaminating Service Animals and Pets.

Action Item

Ensure decontamination messaging is clear and concise, avoiding jargon.

5.4. Long-Term Registry and Follow-up

An important element of planning is establishing procedures and identifying resources forinitiating a registry that will track all potentially affected people (responders, emergency workers, public, etc.).

Similar to information collected at Points of Dispensing (PODs) during response to infectious diseases, data collection for a radiation registry should start at CRCs or mass care shelters to identify and contact people who may require short-term medical follow-up or long-term health monitoring. Acknowledging that many CRCs may only be able to collect basic information such as name, location during the event, and contact information for future follow-up, the registry should also collect radiation-related information, such as contamination measurements and distance from the incident, from all individuals who visit the CRC or mass care shelter. This includes the public, first responders, public health workers, and medical staff. Information can be collected using paper forms with digital data entered at a later time. Use of paper forms is a common option in CRC plans, as they require less trained staff. Tools such as the CDC CRC Electronic Data Collection Tool (CRC eTool); Agency for Toxic Substances and Disease Registry (ATSDR) Rapid Response Registry (RRR) and Epi Contact Assessment Symptom Exposure (Epi CASE); and NIOSH Emergency Responder Health Monitoring and Surveillance (ERHMS) system can also be used to gather and assess data, though these tools may require more staff and training to utilize.

Key considerations for radiation registry establishment and data collection include:

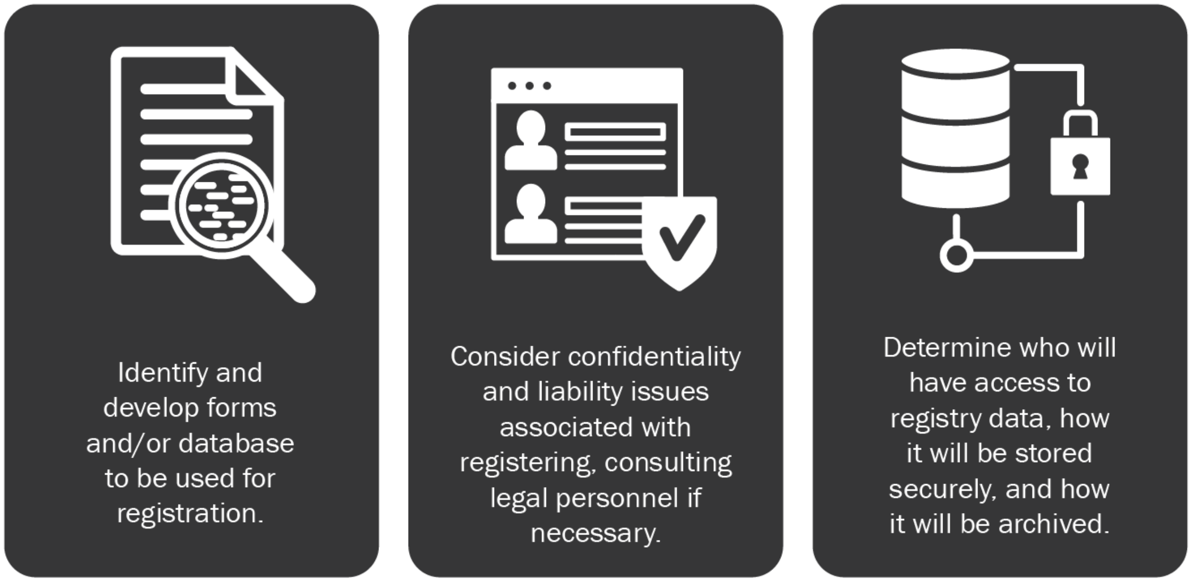


Figure 35: Radiation Registry Considerations

Action Item

- Identify and develop forms and/or databases to be used for registration.
- Determine who will have access to registry data, how it will be stored securely, and how it will be archived.

SLTT agencies are responsible for population monitoring following a nuclear or radiological incident. SLTT authorities have a central role in deciding to devote resources to registry establishment and maintenance, while CDC is responsible for assisting relevant authorities with long-term health monitoring, including establishing a radiation registry. ATSDR, an independent operating agency within HHS, is directed by congressional mandate to perform health surveillance and registries and may be a resource for state or locals to use to develop their own registries.

A registry must be established as early as possible following a radiation emergency. Experience from past public health emergencies shows that congressional authorization, appropriation, and construction of code and statute to set up and operate a public health surveillance system or registry can take one to two years. Therefore, the process must begin during emergency response preparation planning. Additionally, during response, the emergency management community will be focused on lifesaving activities, so they will be unable to focus on registry system decisions. Therefore, it is critical to plan for the radiation registry before an incident occurs. Analyzing effective methods to transfer information collected immediately after the incident to a registry may take months or years.

Action Item

Plan to establish a registry as soon as possible.

Consider the following key factors when planning for a radiation registry:

- **Engage Stakeholders**: Bringing key stakeholders together before an emergency is essential for building trust, discussing scientific and sociopolitical challenges related to radiation registries, and identifying disagreements. Expected radiation registry stakeholders include anyone with a mission, interest, influence, or expectations related to the radiation registry.

- **Define the Purpose of a Registry**: The purpose of the registry defines who to enroll; methods to reach out to those individuals; what data must be collected; the consent, authorization, and legal requirements that govern the registry; and the resources needed to operate the registry, including personnel and funding. Potential purposes of a radiation registry are:
    - Medical monitoring of those who exhibit clinical symptoms related to ARS
    - Health monitoring of those affected (exposure, contamination, mental health)
    - Access to healthcare for those affected
    - Research on radiation health effects
    - Social recognition of the tragedy and the effects it has on the population
    - Outreach to those affected, such as updates on scientific and medical developments or programs or policies relevant to the incident
    - Financial compensation for victims

- **Identify Stakeholders and Roles and Responsibilities**: Currently, the roles and responsibilities for establishing long-term health monitoring systems following a nuclear or radiological incident are not well defined. Stakeholder agreement on roles and responsibilities prior to an incident produces an agreed upon framework to alleviate confusion, duplicative or conflicting activities, and competition for scarce resources.
    - The state and local public health community expects the federal government (ATSDR) to play a central role in setting up a radiation registry. Federal involvement could manifest in a number of ways:
        - ATSDR, with input from stakeholders, develops a framework for setting up a radiation registry, but its implementation is the responsibility of state or local health authorities.

- ATSDR, with input from stakeholders, creates a radiation registry template and transfers it to state or local authorities to implement and operate the registry.
- ATSDR, with input from stakeholders, implements and operates a centralized registry.
- State or local health authorities perform data collection for the registry and transfer the data to ATSDR, which is responsible for operating a centralized registry and for reporting the adverse outcomes.

Given that capabilities differ considerably across the United States, planners should identify their local and state capabilities to determine the most likely approach for their jurisdiction.

Key Pre-Incident Planning Activities for Setting up Radiation Registry

- Capture basic information of affected population
- Screen for radiation contamination and assess exposure
- Consider software/hardware needs

- **Link Immediate Response to Long-Term Follow-up:** When developing a radiation registry, three key pre-incident planning areas can improve information transferring:
  - Capture contact information on those affected. Although it is important to collect data for follow-up, it should not impact the responders' ability to accomplish lifesaving tasks and early response priorities. If resources are limited, it is sufficient to collect only a few critical fields, such as name and contact information, in order to gather additional data at a later date.
  - Screen for radiation contamination and assess exposure. Screening for radiation contamination and early exposure assessment contributes to initial projections about the incident and its health effects on the affected community. This also provides an initial evaluation of the incident's effect on an individual's health. Therefore, screening for radiation contamination and early exposure assessment can affect decisions about the need for a registry and individuals' participation.
  - Consider digital data system's requirements. Transferring information collected during the early response phase to a registry may result in unanticipated inconsistencies across systems/entities. To the extent possible, planners should consider common data fields to leverage existing systems when building a radiation registry.
- **Include Radiation Dose Threshold as a Registry Inclusion Criterion**: It is likely that the decision about what dose threshold (if any) is appropriate for a radiation registry in the U.S. will be a political decision, driven by social considerations and only partly informed by scientific evidence. Advance planning can balance these considerations.

Planners must find or develop registries and tracking systems that suit their jurisdiction's particular needs. For reference, see Appendix 5.6: Available Tools for Tracking and Monitoring People.

Coordination Opportunity

State and local planners should coordinate with Radiation Control Program Directors to determine a preliminary radiation dose threshold for inclusion in a registry. Discuss with nearby states to ensure consistency in approach.

6. Communications and Public Preparedness

Though there are a variety of nuclear detonation scenarios, communications strategies for all scenarios are the same—provide immediate, clear, and instructive messages for public health and safety, regardless of size and HOB. The distinction between various types of bursts will ultimately affect the messages themselves because burst height affects key considerations like the presence or absence of fallout and the possibility of mass fires. The magnitude of the detonation will affect the number of people impacted. Even with variables, planners can learn to coordinate messages with technical bodies and distribute Integrated Public Alert and Warning System (IPAWS) and other public safety messages under the ICS.

Coordination Opportunity

Federal, state, and local resources must coordinate to send timely and accurate safety messages.

Knowing that communication will play a critical role in potentially saving thousands of lives, public affairs staff face a daunting challenge of addressing fear and grief while accurately describingprotective actions. Planners should inform public affairs staff that they do not have to create all communications strategy and messaging themselves. Radiation communications experts across the country can share best practices and case studies to help fill gaps in nuclear and radiological emergency preparedness and response communications. For more information, please reference the most current version of *Communicating in the Immediate Aftermath.*

Refer To

- FEMA's *Improvised Nuclear Device Response and Recovery: Communicating in the Immediate Aftermath:* www.fema.gov/sites/default/files/documents/fema_improvised-nuclear-device_communicating-aftermath_june-2013.pdf
- *Exploring Medical and Public Health Preparedness for a Nuclear Incident,* Chapter 5: Implications of Communication, Education, and Information Challenges: doi.org/10.17226/25372

6.1. Pre-Incident Communications Planning

6.1.1. COMMUNITY PREPAREDNESS AND AWARENESS

Radiation is often feared and not well understood. In a nuclear detonation scenario, this is compounded. Most members of the public do not plan for or know how to respond to this type of hazard. In this scenario, preparedness can save more lives than any other aspect of a response.

The public's perception of risk in a nuclear detonation scenario evokes extremely strong emotions because every factor that increases risk perception is present in a nuclear detonation scenario (Covello et al., 1988). Nuclear detonations are hard to understand, imposed, and catastrophic—and a lack of knowledge about the subject makes it difficult for people to feel like they are in control. The future is uncertain, the scenario is unfamiliar, and the hazard is man-made. All these factors make messaging during radiation emergencies incredibly difficult. However, while it will always be imposed and catastrophic, we can help increase the public's perception of control and familiarity through pre-incident education.

It is the responsibility of emergency planners, public information officers (PIOs), community leaders, and emergency and first response personnel to effectively communicate why preparation for a nuclear detonation scenario is essential to surviving it. Without pre-incident knowledge, key messaging, and preparedness steps, people will likely follow the instinct to run from danger, potentially exposing themselves to fatal doses of radiation that could be avoided by sheltering.

Planners can perform two key preparation activities to enhance community preparedness:

Plan and execute nuclear detonation preparedness education campaigns related to other hazards.

Figure 36: Plan and execute preparedness campaigns.

Pre-incident preparedness is a difficult task, regardless of hazard. There is a legacy of public nuclear preparedness campaigns, such as the Cold War's "Duck and Cover," that leave the public skeptical of nuclear detonation preparedness messages.[38] In addition, with a public that associates nuclear detonations with certain death, the sense of futility, fatalism, and hopelessness severely impacts their desire and ability to absorb information and follow instructions.

Gather support for preparedness campaigns from a coalition of decision makers and other public health agencies in your community. Identify the best spokespeople in these groups to assist you in broad-reaching preparedness campaigns.

Leverage all-hazards messaging in preparedness outreach. While these campaigns are necessary, they may be difficult to execute without causing unnecessary concern. Because of resistance to open

[38] Pulled directly from the 2010 edition of this planning guidance, which cited Homeland Security Institute's *Nuclear Incident Communication Planning: Final Report.* (Homeland Security Institute. 2009. *Nuclear Incident Communications Planning: Final Report.* Department of Homeland Security, Office of Health Affairs. RP-08-15-03.)

discussions about nuclear detonations, emergency management agencies and public affairs staff must integrate nuclear detonation messaging into all-hazards messaging.

Utilize National Preparedness Month each September to include nuclear detonation preparedness in larger preparedness campaigns. People are less likely to resist learning about protective actions for a nuclear detonation if they understand that they are applicable to other, more familiar emergencies. If your emergency management group is encouraging people to make an emergency kit or prepare financially for an emergency, adding another hazard to the list for which these actions are protective is less likely to frighten people. It may be useful to introduce CBRN preparedness actions together. Nuclear detonation preparedness can also be integrated into wider radiological and nuclear preparedness. For example, initial protective actions for a nuclear detonation and for a dirty bomb scenario are very similar: people must "Get Inside, Stay Inside, and Stay Tuned" for more instructions.

Action Item

Leverage National Preparedness Month for public outreach and preparedness campaigns.

Use simple, action-oriented language to help your constituents absorb preparedness information. In communicating preparedness information, your strategy and messages must use basic, non-technical language that is easy to understand and translate. Focusing on action helps constituents feel more in control and helps them retain information to make more informed decisions. Empathetically address the public's fear and concern; expressing empathy validates strong emotion and increases public trust.

Action Item

Use simple, action-oriented, empathetic messages to encourage preparedness.

Reinforce and encourage adoption of emergency communication methods. Preparedness campaigns should include information about communications methods that emergency managers and responders will use to reach the public. Campaigns should describe local emergency notification platforms, meanings of various emergency siren tones, and continued encouragement of hand-crank radio acquisition.

Leverage existing NPP preparedness campaigns and communications. NPPs and the FEMA Radiological Emergency Preparedness (REP) Program provide radiological preparedness information to those living near commercial nuclear power facilities. The REP Program has worked with schools to incorporate preparedness information on school calendars and book bag labels to reach out to both parents and students.

Coordination Opportunity

- Coordinate with FEMA's REP Program to leverage existing NPP preparedness campaigns and communications.

- Coordinate with community leaders and influencers to make inroads to different organizations in your jurisdiction.

Plan for teachable moments and approve teachable moment strategies and messages in advance.

A teachable moment is "an event or experience which presents a good opportunity for learning something about a particular aspect of life" (Oxford, 2021). In these moments, something has happened to remind the public about nuclear detonations, but there is no threat. During teachable moments, heightened awareness of a threat or emergency increases the public's desire for knowledge about how to protect themselves and their loved ones. Teachable moments are an opportunity for emergency planners and public information/affairs staff—**in these moments, the public is more willing to listen to preparedness messages without being frightened by the messages themselves.**

Action Item

Prepare in advance to leverage teachable moments quickly and effectively.

Be alert for teachable moments. It is critical to have prepared messages, dissemination outlets,and strategies approved in advance, because increased attention will be brief. Have prepared messaging available and approved so the window of opportunity to educate is not missed.

Recognize that teachable moments may be sparked by different media. As with your preparedness campaign, it may also be useful to group CBRN incidents together. For instance, television shows, movies, podcasts, and other media may discuss a chemical emergency and gain public popularity. Remind residents that, should any type of CBRN incident occur, they should stay inside a sturdy building and monitor information from public officials.

What Would You Do?

A popular television show depicted a terrorist improvised nuclear device (IND) incident in a way that increased public curiosity about surviving an IND. What messages do you have prepared, and who would have to approve them for use to increase public knowledge and preparedness?

Gather organizational support and approval before a teachable moment occurs. Because we cannot predict what might spark a teachable moment, communicators should prepare reassuring and instructive messages with fill-in-the-blank spaces for specific details based on the teachable moment. Discuss your strategy with your management and chain of command and emphasize how important these moments are for broad awareness of safety actions following a nuclear detonation.

Refer To

Access and Functional Needs Toolkit: Integrating a Community Partner Network to Inform Risk Communication Strategies: www.cdc.gov/cpr/readiness/00_docs/CDC_Access_and_Functional_Needs_Toolkit_March2021.pdf

6.1.2. AUDIENCE ASSESSMENT AND PREPARATION

As with any response, it is vital to know who is in the affected area to adequately meet survivor needs and save lives. To communicate effectively, get as specific as possible when defining different audiences and include workers who are likely terrified and grieving but still need to go to work. To reach all audiences, you may need to coordinate with people outside of your direct response community for help. Your existing knowledge as a communicator in your jurisdiction is the building block for all communications planning. It is important to know population density, languages spoken, number of commuters and tourists, previous experience with environmental or physical emergencies, and commonly crowded places. It is important to know who community leaders are and who may be a good spokesperson during an emergency. This information can help for all types of emergencies.

Refer To

- *Communicating Radiation Risks*, EPA, 2007: tinyurl.com/2p84d2bz
- *Community Emergency Planning Toolkit for NYC Community and Faith-Based Networks,* New York City, 2019: www1.nyc.gov/site/em/ready/community-preparedness.page
- *Ventura County Nuclear Safety Guide:* s29710.pcdn.co/wp-content/uploads/2018/05/VC-Nuclear-Safety-18pp-Education-Guide-Downloadable-FINAL.pdf

Aim to get input on preparedness activities from outside your current emergency response community; the *Community Emergency Planning Toolkit for New York City (NYC*) is an excellent reference to begin preparedness conversations with a variety of stakeholder groups.

Communicating with parents of children in schools and daycares will be exceptionally difficult and contradict parents' instincts to reunite with their children immediately.

Develop communication strategies for parents of children in schools and daycares. Your jurisdiction's outreach strategy must communicate the necessity of staying indoors, even when children are not with their parents. Preparedness messaging must incorporate school and daycare safety plans and explain the dangers of parents attempting to pick up their children.

Coordination Opportunity

Work with schools and daycares to ensure parents do not attempt to retrieve children in unsafe conditions.

Incorporate nuclear detonation preparedness into existing emergency drills. While schools and daycares do not exercise nuclear detonation drills specifically, they likely exercise shelter-in-place drills for tornadoes, earthquakes, and other severe weather incidents. At a minimum, school administrators should know how these relate to nuclear detonation protective actions.

Identify responder audiences and prepare messaging for those that need to shelter following a detonation.

Everything in this document is considered critical to saving the lives of people in the SDZ, MDZ, LDZ, and DRZ. However, responders cannot save lives if they are exposed to fatal levels of radiation or otherwise disabled. Responder messaging must be prioritized, to protect them and enable their lifesaving work.

Shelter-in-place messaging for responders within the DRZ is critical. It is critical that first responders, remain sheltered while in the DRZ. Train responders in a manner that emphasizes that their patience, even in the face of a nuclear detonation, is required so they can save others. Be sure to include how responders will be notified that they are in the DRZ.

Action Item

Develop communications strategies that specifically address first responders.

Reference federal radiation exposure guidance and safety guidelines in communications for responders. Many emergency workers are not familiar with radiation protection and may not be comfortable working in a radiation environment. Ensure responders understand the differences in radiation risks during a nuclear detonation relative to other radiation-related emergencies. Responders must be properly informed about the risks associated with the areas in which they may be working. Just-in-time training material is critical to address this issue.

Refer To

PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents: www.epa.gov/radiation/protective-action-guides-pags

Communications staff's ability to define audiences will be useful for first responder community outreach. While most pre-incident responder education and training is performed by emergency managers and first responder groups, it can be enhanced by involving skilled communications experts. Communications staff have specific message development skills and can assist trainers, supervisors, and planners with language and tone choices to enhance messaging, even if others will ultimately be responsible for these conversations and trainings.

Identify and educate non-traditional emergency workers. Outreach to non-traditional emergency workers, such as public works employees, must emphasize their critical role in response and explain the risks associated with it. Engaging these groups early, before an incident happens, is critical for anticipating their needs during response (Benedek et al., 2007). When analyzing community needs, note places and services that are visited daily to predict potential non-traditional emergency responders.

Action Item

Identify and educate non-traditional emergency workers critical to emergency response.

Develop communications to ensure responders and their families understand radiation risks and other response hazards. Responders' families will be concerned about their loved ones working in the area. Communication is important for families to understand guidelines and protections in place to minimize responder dose and risk.

6.1.3. INTERJURISDICTIONAL RELATIONSHIPS AND MEMORANDA OF UNDERSTANDING (MOUS)

When faced with this type of resource-straining incident, officials and responders must know whom to rely on for assistance. Cultivating and maintaining assistance relationships with neighboring towns, cities, and counties, as well as state and federal response organizations, is critical to ensure this aid.

Pre-established relationships with neighboring communities are vital to facilitate message dissemination support during nuclear detonation response.

Share and coordinate nuclear detonation plans with neighboring jurisdictions. Coordination for a nuclear detonation response is similar to coordination for other incidents and will assist your jurisdiction during other responses. Planners should consider exercising plans with these jurisdictions and establishing them as trusted agents in your emergency management structure. These relationships enable neighboring townships or counties to effectively reach your communities. While doing so, familiarize neighboring jurisdictions with your community's news acquisition preferences. Understanding how your residents get news will empower other jurisdictions to effectively respond in your jurisdiction. Identifying a multi-jurisdictional or regional approach to communications is critical to immediately publish time-critical safety messages.

Coordination Opportunity

Coordinate nuclear detonation plans with neighboring jurisdictions that will be tasked to support your jurisdiction following a nuclear detonation.

Review existing agreements to ensure communications and public information support are included. Establish the importance of communication in saving lives early in the planning process. Doing so will assist you throughout a response.

Detectable radiation downwind of the detonation will likely cause concern in members of the public and in responders. Though the detonation will primarily and profoundly impact the area in which the detonation occurs, a possibility of detectable radiation levels traveling to nearby jurisdictions is certainly present. Emergency planners and PIOs in nearby jurisdictions should be aware that detectable radiation will vary depending on weather and atmospheric conditions and prepare for an onslaught of concerned questions from members of the public, exacerbated by the trauma of a domestic nuclear detonation. Nationwide, emergency managers should remain aware of federal modeling and monitoring for radioactive material.

FEMA's Radiological Operations Support Specialist (ROSS) program can assist with technical communications and should be incorporated into plans.

Refer To

FEMA's ROSS Information Sheet: www.fema.gov/sites/default/files/2020-07/fema_cbrn-ross.pdf

Ensure radiation expertise is available to support message development. While not every jurisdiction has a radiation expert on staff, this expertise is critical to assist communications staff with their messaging. This expert input is integral for explaining radiation risks, clarifying protective actions, and addressing concerns about radiation doses. The value of radiation experts for this response cannot be understated. Jurisdictions should identify these experts within their community and address any expertise gaps that may exist.

Integrate ROSS into plans to fill identified gaps. Plans should include coordination with the ROSS program. ROSS can assist communications staff with radiation technical support for planning and response operations. ROSS are trained to review information to provide situational awareness and support message consistency across responding jurisdictions. Connect with the ROSS program by emailing **FEMA-ROSS@FEMA.DHS.GOV.**

6.2. Immediate Response Communications Priorities

It will be incredibly difficult to reach those affected by a nuclear detonation. Even after natural disasters, it can take days to months to fully restore cellphone capabilities. To fully appreciate the importance of pre-incident preparedness, it is necessary to understand the impacts that nuclear detonations have on communications infrastructure. Communication capabilities following a nuclear detonation depend on the amount of remaining infrastructure, and pre-existing community plans and preparations. For more information about communications capabilities following a nuclear detonation, see Chapter 7.

6.2.1. SAFETY INSTRUCTION DISSEMINATION

Even if there is a total shift in public awareness of nuclear detonation preparedness actions, the public will require just-in-time messages that direct them to get inside and stay inside, self-decontaminate, and wait for further instructions. **Your jurisdiction's ability to provide those messages hinges on three critical factors:**

advance preparation of messages, immediate dissemination of messages, and redundant dissemination outlets to compensate for severely damaged infrastructure.

Pre-scripted and approved messaging increases public communication effectiveness when minutes matter.

Leverage pre-scripted, vetted, and federal agency–approved messages. FEMA's *Improvised Nuclear Device Response and Recovery: Communicating in the Immediate Aftermath (June 2013)* contains anticipated questions and answers for use immediately following a nuclear detonation. These messages have been reviewed by all federal response agencies for immediate use in your jurisdiction. This communications guide answers many anticipated questions, and provides scientifically accurate safety messages in simple, effective language. Your public affairs staff should become familiar with and practice using this document.

Refer To

FEMA's *Improvised Nuclear Device Response and Recovery: Communicating in the Immediate Aftermath (June 2013):* www.fema.gov/sites/default/files/documents/fema_improvised-nuclear-device_communicating-aftermath_june-2013.pdf

Adapt and create messages that specifically address the concerns of and populations in your community. Existing pre-scripted messages are not exhaustive of all critical communications considerations. There are many questions that depend on state and local response, as well as specific geographical questions that cannot be answered at the federal level. Draft a list of anticipated questions from the public based on the interests and needs of your community. Use anticipated questions and pre-scripted messages in exercises. Include members of the response community from all levels—decision makers, first responders, public works staff, and communicators—and use this opportunity to gather additional questions.

Action Item

Ensure messaging addresses the unique concerns of your community.

Use plain language and message mapping tools to develop effective communications. When anticipating questions and scripting answers, consider both broad audiences (people in the blast damage zones, the DRZ and surrounding area, and the national and international community) and targeted audiences (non-English speakers, hospital and nursing home staff and patients, people experiencing homelessness, farmers, etc.). For messages to be effective, they must be understood by the intended audience. It is important to keep messages simple, accurate, and consistent, using plain language as much as possible. Research shows that some common emergency response terms and phrases, such as "shelter-in-place," are not understood by the public. Avoid jargon, technical terms, and acronyms.

Refer To

Communicating Radiation Risks, EPA, 2007: tinyurl.com/2p84d2bz

Prepare people for safety guidance and instruction updates. Emergencies evolve over time, and safety messages will be updated frequently to reflect changing conditions and new information. In messaging studies, respondents preferred the phrase "instructions will be updated" over "instructions may change," because it contextualized why safety instructions may evolve throughout response. "Updated" implies further information, while "change" implies instructions were wrong (National Center for Environmental Health Radiation Studies Branch & CDC, 2011).

Disseminate safety messages across all possible channels to save lives.

Based on modeling from DOE National Laboratories, deaths and severe injuries from fallout can be almost eliminated if people get inside before an incident happens. Likewise, deaths and injuries are drastically reduced if people receive the message soon after a detonation occurs. For more information on adequate shelter, refer to Chapter 3.

Action Item

Prepare messages for immediate dissemination across all possible channels.

Encourage all jurisdictions to disseminate a consistent early message of "Get Inside, Stay Inside, Stay Tuned." DHS published an update to ESF-15: SOP in July 2019 establishing that response organizations at all levels of government are empowered to broadcast immediate safety messages. If there has been a confirmed nuclear detonation, DHS guidance says that "all Federal, state, local, tribal or territorial agencies with appropriate public health and safety missions should disseminate the 'Get Inside, Stay Inside, and Stay Tuned' message through all available communication channels. This message is approved for immediate dissemination."

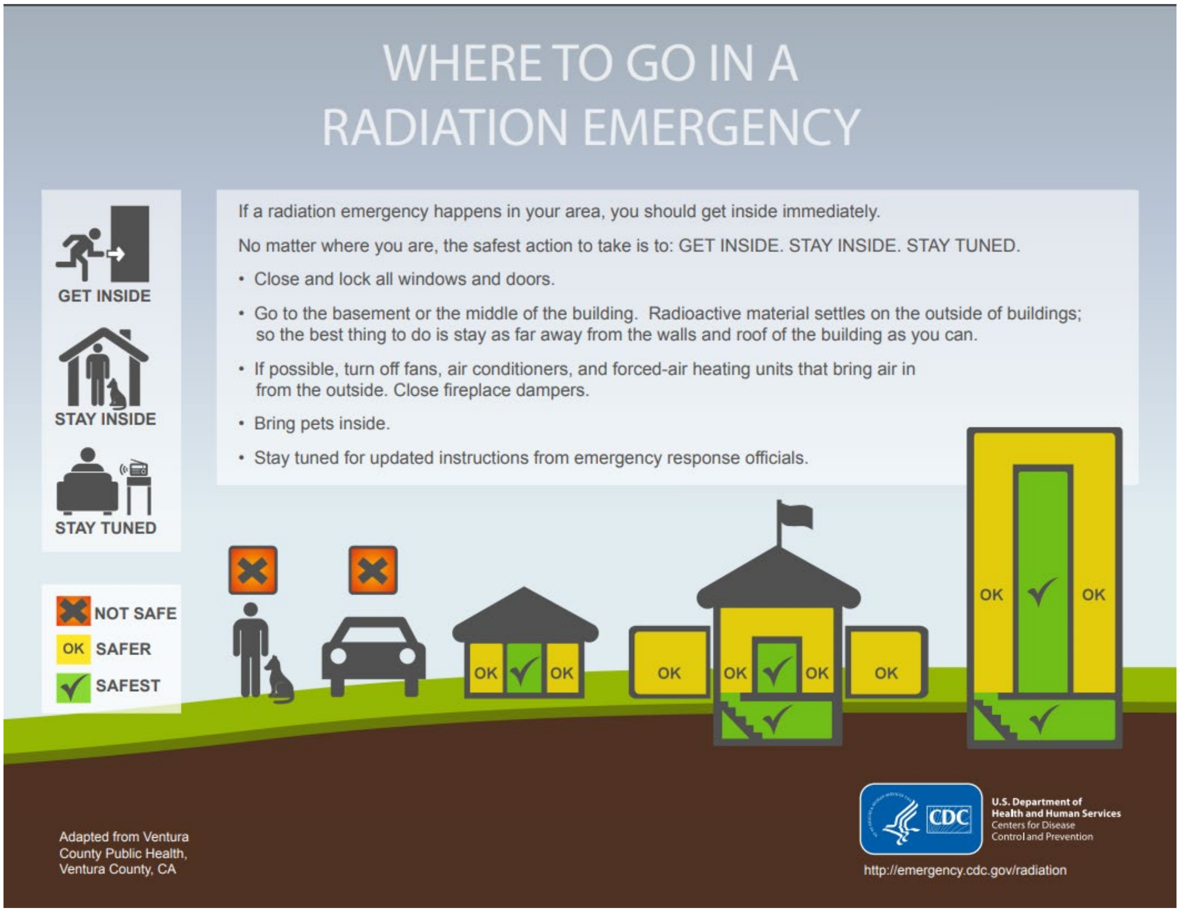


Figure 37: Example infographic showing where to go during a radiation emergency developed by the CDC (CDC, 2020).

Action Item

Ensure plans include consistent early dissemination of "Get Inside, Stay Inside, Stay Tuned" messaging.

Refer To

FEMA, Emergency Support Function 15 - External Affairs, Annex N: www.fema.gov/sites/default/files/2020-07/fema_ESF_15_External-Affairs.pdf

Coordination is critical to ensure initial protective action information reaches affected populations immediately following a nuclear detonation. The first action for every local, state, and federal agency is to push safety messages through every possible outlet. Repeating messages through all levels of government reinforces that the messages are credible. When cultivating relationships with nearby jurisdictions, community organizations, and federal and state partners, establish how essential repeated and consistent safety messages are. Your organization's relationship with others may be the difference between people seeing a single message and disregarding it or seeing repetitions of the same message and following the instructions.

Plan for variable communication within the impacted area. There will be significant damage to infrastructure that will affect your ability to communicate with incident command staff, responders, the public, and other jurisdictions. Reference the Communications Infrastructure section later in this chapter for more information.

Develop a plan for preapproved message distribution before ICS or JIC/JIS (Joint Information System) structures are activated. It is necessary to prepare plans that authorize response personnel to disseminate messages when they are unable to contact an EOC or JIC/JIS. Include these specific communications tasks in planning, incorporating relevant implications and considerations.

What Would You Do?

What would you do if you were unable to communicate with your approval chain for message delivery? How would you ensure critical life safety messages were disseminated?

Agile and immediate communications channels are integral and necessary to send out frequent updates.

Cultivate a social media presence and following before an incident to build trust and confidence. Using consistent best practices, communications staff should disseminate safety messages on all agency or jurisdiction platforms. Planners should ensure their agencies and jurisdictions have verified social media accounts and are providing regular updates through these channels. Knowing where to look for information reduces the public's reaction time—in a nuclear detonation scenario, these minutes matter.

Action Item

Invest in social media development now—cultivate a social media presence and following before an incident to build credibility for that channel.

Predetermine communication channel options based on expected nuclear detonation impacts and pre-identified preferred message channels. Your jurisdiction's plans should include a standard operating procedure (SOP) regarding safety instruction communication methods. Prioritize platforms your constituents visit and use frequently. Make sure to publish safety messages across all the platforms your jurisdiction uses. These methods should be informed by community usage of and familiarity with specific platforms and outlets. Additional, alternate communication methods must be publicized in preparedness campaigns, so people know where to find information if certain systems are down.

This planning guidance outlines zones where the types and severity of impacts can be estimated. Planning should consider each of these zones and structure specific communication pathway priorities around them. For example, because most communication modes will be impaired in the MDZ, deployable cell towers or flyover messaging may be prioritized.

Incorporate procedures for communications staff to monitor and quickly correctconflicting or inaccurate information. With many response organizations and worldwide interest in nuclear detonations, there is a high likelihood of conflicting and incorrect information dissemination. Communications staff should incorporate appropriate subject matter experts to quickly assess questionable messages and assist with drafting messages to counter or augment others.

What Would You Do?

If social media posts encouraged people to drink iodine to protect themselves from radiation, what would you do? How would you confront this rumor?

Prioritize frequent updates to limit information obtained from unofficial sources. Frequent updates, even when no new information is available, are recommended to ensure people continue to seek information from you instead of unofficial sources. Set expectations for update timing early on and meet them. Simple explanations of ongoing work, why it is valuable for the public, and how it informs safety instructions provides reassurance.

Utilize family and social connections in your community to share important messages. As people attempt to reach family and friends in the affected area, it is critical that they have the most up-to-date safety instructions because they may be the first to reach those sheltering in the affected area. You can address these audiences nationally and encourage them to relay safety messages.

Geo-targeting should be a component of your communications strategy.

Wireless Emergency Alerts (WEAs) is a public safety system that allows customers with compatible mobile devices to receive geographically targeted, text-like messages alerting them of imminent threats in their area. This can be leveraged in different stages of a response. For example, if your jurisdiction has determined that people in the affected area should self-evacuate, you can precisely target people in those locations to notify them to evacuate and avoid the DRZ. Chapter 7 provides additional details about WEAs.

Action Item

Include geo-targeting in your communications strategy.

Plan to send different messages to varying impact areas to ensure proper action is taken in each zone. After "Get Inside, Stay Inside, Stay Tuned" is immediately disseminated, communications must transition to specifically address each zone within the affected area. Messages should be drafted for each area, and targeted message delivery systems should be established.

Practice coordinating and delivering targeted messages. Similar to testing tornado sirens, testing WEA capabilities within your community can help identify gaps and capabilities and may be a good way to engage your jurisdiction in preparedness activities during National Preparedness Month. Practicing geo-targeted message deployment is necessary to effectively utilize this strategy during an emergency.

Engage local businesses and organizations to practice amplifying emergency messages. Reach out to other businesses that record customer contact information. Is there a local coffee shop everyone visits before going to work that has an online loyalty program? Local organizations may be able to assist in message delivery, but relationships must be established before the incident occurs.

Coordination Opportunity

Include local businesses in exercises to build trust and practice emergency communication. Do educational outreach via talks and demonstrations of equipment and monitoring.

Explaining health risks and benefits related to critical decisions is crucial for public acceptance and compliance with safety instructions.

Understanding radiation risk is crucial for public and responder safety instruction compliance. Communicating radiation risks and protection principles is necessary for both responders and the public to understand that their actions can protect them from short- and long-term health effects. Depending on the protective actions, even a brief explanation can increase compliance. Relating protective actions to other incidents with similar guidance, like sheltering for tornadoes, can also increase understanding and compliance with safety instruction. Radiation risk and simple technical messaging are integrated into all the federal government's pre-scripted radiation emergency messaging but should be noted in your jurisdiction's plans as well.

Action Item

Include risks and benefits explanations in messaging to increase public acceptance and compliance with safety instructions.

Integrate radiation technical advisors or ROSS as early as possible, to translate technical information and inform communicators. Identify radiation professionals in your community or state. These individuals can be found in your state radiation control program, established dose assessment or radiation advisory groups, or ROSS in other radiation-related industries. ROSSs are specifically trained to simplify complex radiation content into simpler terms and assist with public messaging activities. Some safety actions may seem contradictory to your community; work with a technical expert to develop accurate, clear messages that deconflict identified issues.

Emphasize communications skills across disciplines, not solely the public information field. In an emergency, everyone involved in response is a potential spokesperson—to the public, to the media, and to other responders. Communications staff should work with technical experts, first responders, and elected officials, all of whom may be the most trusted spokespeople, to provide media training and practice before an incident occurs.

Coordination Opportunity

Anticipate technical support from radiation specialists and incorporate them in the communications plan.

It is critical for everyone to practice effective communication techniques, not just communications staff—train personnel in other response positions.

Determine a public information approval chain within your organization and exercise the process regularly.

Develop a message review plan, with appropriate approval levels, and exercise this plan frequently. Many jurisdictions already have message review plans or approval chains that have been used in the past. The scale of a nuclear detonation response will be much larger than any other emergency response planned for or undertaken by your jurisdiction. In your plan, consider additional steps that may be necessary to review and approve messages before dissemination. **Reduce the amount of time it takes to create and deploy a message by briefing approvers on needed messaging before an emergency happens.**

Plan for frequent review and updates as message needs change. Data will be gathered by field teams and analyzed by scientists in increasing amounts as the response continues. Updates to current messages will be necessary, even if changes are limited. Review previously approved messaging on a regular basis to ensure accuracy. Address this with decision makers in your review chain, so they anticipate reviewing and approving similar messages multiple times.

Action Item

Develop a public information approval chain and exercise the process for nuclear detonations frequently. Wherever possible, integrate similar approval chains into all-hazards planning and use other disaster exercises to exercise the approval chain as well.

6.2.2. COMMUNICATIONS INFRASTRUCTURE

The blast effects of a nuclear detonation will critically damage cell towers, telephone lines, power lines,and other integral communications infrastructure such as backhaul and portions of the core network. Therefore, replacing cell towers and telephone lines alone may be insufficient to restore communications infrastructure. This is the largest challenge in communicating with the public following a nuclear detonation.

Infrastructure damage will be the main challenge in communicating with the affected community and responders.

Preparedness is the only way to ensure community awareness and adoption of safety instructions. To ensure your community knows what to do—without prompting from a website, WEA, or social media post—prepare your community in advance to know signs of a nuclear detonation and proper protective actions.

Providing appropriate information ahead of time ensures proper information is disseminated during response. Well-briefed response staff are integral to communications activities because the first information people receive may be from first responders in the affected area. Developing and distributing key information cards for responders can help first response teams spread critical safety messages within affected areas.

Prioritize communications infrastructure restoration. Along with commercial systems, public safety systems, such as land and mobile radio and 911 call centers, may suffer communications failures. Though public safety systems may be hardened against blast damage, residents' ability to connect with the designated Public Safety Answering Point (PSAP)[39] may be hindered by cell tower or telephone pole damage. These systems are critical for emergency responders and need to be restored as quickly as possible. Additionally, when responding to a major disaster, such as a nuclear detonation, FEMA activates the Communications Annex of the NRF, ESF-2. ESF-2 enables coordination with the private sector, state, and local entities to restore commercial communications infrastructure, public safety networks, and emergencyresponder networks.

Identify less-common, low-tech methods for communicating in severe environments. Low-tech methods, such as sirens, HAM radio, and flyer drops, will likely be necessary to reach people in the immediately affected area following a nuclear detonation.

Refer To

ESF-2 - Communications Annex: www.fema.gov/pdf/emergency/nrf/nrf-esf-02.pdf

Cell towers will be overloaded with phone calls and text messages, making communications sluggish.

Plans must emphasize sending protective action and safety messages through all available channels. It will be unclear which methods work, but understanding the challenges posed by certain methods is critical.

Encourage texting over calling. Without exception, emergencies prompt an avalanche of calls, texts, and social media messages to those in affected areas. Most response organizations have pre-scripted or previously published messages that indicate people should use text messaging instead of calling to increase their chance of connecting with loved ones.

As mentioned later in Chapter 7, FEMA IPAWS' WEAs use Short Message Service-Cell Broadcast (SMS-CB), a one-to-many service, that simultaneously delivers messages to multiple recipients in a specified area. By using SMS-CB as the delivery service technology, WEAs avoid mobile device congestion issues experienced by traditional voice and text messaging SMS-Point to Point (SMS-PP) alerting services.

[39] For more information on PSAPs, see Chapter 7.

Action Item

Prioritize texting systems over calling systems when attempting to reach those in the affected area.

Coordinate with cell service providers in your area. Cell towers generally have two branches of utility: voice/text and data.

During emergencies, carriers will reallocate branches to support 911 and emergency calling, sometimes completely cutting off data utility to give emergency calls and text messages a better chance of connecting. This reallocation can be automatic or controlled manually. Planners should talk to the providers in their area to determine what the provider's trigger points are, what considerations the provider makes in allocation during emergencies, and what geographic considerations may need to go into connectivity planning. Cellphone service providers should also be able to describe mobile assets and restoration planning; planners can leverage this information across all emergency planning, not just in nuclear detonation plans. **Damage to electronic communications equipment by the EMP will not be permanent outside of SDZ.**

EMPs have the potential to damage electronic equipment near the detonation.

Most electronic equipment will be operable after a reset. Service providers should plan for regional service interruptions due to infrastructure instability. Most communication equipment in the region will be functional provided that it is on battery or emergency power, not physically damaged, and its associated mobile switching center or central office is still operational. Some temporary upsets to electronic equipment may occur within a few miles of the detonation but can recover by reset or power cycle. Within the MDZ, there will be building collapse and downed utility lines (for more information see Chapter 1, Section 1.1). Permanent damage to electronics will generally be limited to within the MDZ from blast and EMP effects, although some isolated power surges can damage unprotected communications equipment plugged into wall sockets up to 9 miles away.

Planners should encourage residents to download national and/or local all-hazards preparedness information or applications on their phones or tablets that includes nuclear detonation response guidance. Infrastructure damage may disable communication electronics. Power and phone lines will probably be damaged, preventing cellphones from connecting even if they are functional.

For more information regarding EMP effects, see Appendix 1.1: EMP, HEMP, and GMD.

Portable connectivity technology is constantly improving.

Pre-coordinate portable connectivity technology through FEMA and state-level resources to re-establish connectivity in the affected area. In many emergencies, jurisdictions rely on mobile cell towers to reestablish connectivity in affected areas. Cell providers use Cell on Wheels/Wings (COWS), Cell on Light Trucks (COLTS), Cellular Repeater on Wheels (CROW), and Generator on A Trailer (GOAT) to provide this capability. FEMA's strategic stockpile also contains mobile cell towers for this purpose.

Coordination Opportunity

Pre-coordinate portable connectivity resources with FEMA and state-level officials.

Identify new networks available to ensure incorporation in communication and infrastructure plans. Follow updates in communications-restoration technology and incorporate proven methods into planning for communication restoration following an emergency.

6.2.3. WORLDWIDE MEDIA INTEREST

A nuclear detonation will attract 24-hour, multi-platform, multi-outlet coverage across the globe. This interest will be overwhelming for any one jurisdiction. Prior coordination with nearby jurisdictions, state communications offices, and federal communicators will help public information staff at all levels address global questions and concerns.

Action Item

Coordinate with nearby jurisdictions in advance, to ensure public information staff have necessary assistance.

News outlets and media publications can broadly disseminate safety messages and combat rumors and misinformation.

Coordinate with and educate media outlets before, during, and after an incident to effectively coordinate messages throughout the entire impacted area. Advanced knowledge will ensure the media reinforces protective action messages. During the first operational response periods, your message to the public and the press must remain clear, concise, and consistent. Focus messaging on what the public can do to protect themselves.

Coordination Opportunity

Coordinate with media outlets prior to incidents to ensure effective and consistent messaging during response.

Refer To

Crisis and Emergency Risk Communication (CERC): Media training and resources are available for PIOs and other public health and emergency response workers.

Prepare a strategy to prioritize requests and catalog approved answers to questions from the press and public; exercise this strategy regularly.

Anticipate communications staff being overwhelmed and establish priorities to keep limited communications staff focused. Your typical PIO staff will be immediately overwhelmed by requests for information, press inquiries, and public inquiries. Prioritizing information needs will be critical to the response's efficacy.

Create a bank of approved message to answer common and repeated questions. Approve responses for the press and public, and catalog the questions received and answers sent. Reusing responses increases timeliness of delivery.

Action Item

Prioritizing information requests from responders,the press, and the public is critical and should be practiced and exercised regularly.

Store approved messages for easy access across jurisdictions. Identifying appropriate cataloging methods for approved messages can be a challenge. Whether you choose a shared document, a database, or other method, the entire public affairs team and anyone staffing a public affairs position must have access. Establishing a message-sharing strategy before an incident happens, exercising it, and troubleshooting challenges are recommended.

Depending on the command structure, you may want to give access to people outside of your organization. Whether you use a system that can allow for outside access or note that it may be a technological problem, make sure to address this in your plan.

6.2.4. INTRAORGANIZATIONAL COMMUNICATION CHALLENGES

To sustain response, your organization must emphasize information sharing, prioritize your staff's needs, and ensure staff have the timeand space to take care of their loved ones. Because every moment ofwork matters, effective internal communications are as important as external communications to response activities.

Protective actions and situational awareness must be coordinated beyond your ICS structure.

Well-informed staff can serve as official information ambassadors and broadcast reliable information to their loved ones and networks. As with other responders, communications staff can be a trusted source of information in their communities and networks. Their relationships with friends, family members and loved ones can be leveraged to disseminate accurate and actionable information, as well as combat rumors and misinformation.

Action Item

Keep staff well informed to both serve as conduits for official information and provide a critical sense of control during the response.

Internal communications should include routine information balanced with critical messaging. An internal crisis communications plan should be part of your overarching communications strategy. In addition to acknowledging concerns about your staff's friends, family members, and responding coworkers, there will also be long-term logistical questions about payroll and health care. Remaining mindful of staff needs will increase trust and help your jurisdiction prepare for a long response and recovery process.

Leverage existing information-sharing structures throughout organizations. Organization-wide email listservs, mass notification systems, and even verbal updates give staff a chance to ask questions and provide an outlet for their concerns and questions. Providing response information will mitigate some of the anxiety and distress that will be present due to the scale of this incident.

Coordination Opportunity

Incorporate pre-existing sharing networks, like listservs and mass notification systems, into response plans.

Involve communications staff in critical decision-making to maintain a COP that informs consistent messaging. Planners must consider how the communications team will remain aware of the overall COP to ensure messages are drafted and released when they are most effective. If communications staff are not involved in critical discussions as decisions are made, they will struggle to keep messaging current, especially in the first days of a nuclear detonation incident.

Coordination Opportunity

Incorporate communications staff in all areas of the response to identify response priorities, increase message consistency, and gain insight on potential public message issues.

6.2.5. LOSS OF LIFE MESSAGING

A nuclear detonation will be one of the highest mass-casualty incidents in U.S. history. Death tolls will range from tens to hundreds of thousands, and people will sustain injuries for miles surrounding the detonation site. Ultimately, there are some bodies that responders will never be able to recover. **Whether you are out in the field, planning for mobile morgues or writing fatality messages, dealing with the sheer magnitude of fatalities will be amongst the more harrowing aspects of a nuclear detonation response.**

Discussing death toll and casualty counts will be an ongoing challenge and must be treated with care and respect.

Prepare to release messages with the best information possible, which may not be complete or exact. Questions about the total number of people lost and the total number of people injured will be constant. There is no perfect way to acknowledge and answer these questions. Pain, loss, and grief will always be attached to this incident, and no matter what, your response community will likely never have a firm count of the number of people who died and the number of people who were injured. Acknowledging this uncertainty is critical when preparing such messages.

There is little advice on how exactly to do this, and there is no template to follow. There is simply the need to do it; lean into the feelings of the impossibility of the situation, and write with compassion, vulnerability, and strength. Staff should know that there is no right answer to this question—they should use what they would want to hear as a starting point and work from there. Ultimately, your message will help your community begin the recovery process and provide a sliver of closure and comfort to people who have lost a great deal.

Determine the most effective spokesperson to deliver messages about the death toll in your community. Communicating respect and care in your answers to these questions will be crucial for public trust. Acknowledging the loss of thousands of people must be carefully expressed and should come from a trusted member of response activities—likely a trusted member of the affected community. It is OK to acknowledge the uncertainty surrounding the number of people lost, but this must be coupled with care for and commitment to the loved ones of those who died. This will increase the public’s confidence that fatality management is being handled with the utmost care and respect. Never speculate on the conditions or numbers of people who have been recovered from the scene; simply stick to the facts of what response can confirm (EPA, 2007).

Plan to enlist the assistance of professionals who routinely communicate about death and grief. There are professions such as medical examiners and funeral directors who deal daily with death and communicating with people affected by it. While they will likely not have considered the large scale of this incident, they can offer support in a sensitive and emotionally charged situation.

Recognize and respect the emotions of the responders tasked with fatality-related work.

Fatality management and body recovery will be a constant reminder of how many people were lost. Throughout the recovery phase, responders, recovery workers, and special teams will continue to recover bodies from the affected area. This will be an ongoing source of extreme stress for emergency responders and recovery workers. Your communications team must take special care in responding to questions about the health of responders in order to keep a high level of trust between organizations and your communications team. Do not diminish the effects of the response on your responders. Communicate with first response organizations’ management about how they would like to address the mental health of all responders.

Work closely with mental health professionals to meet the needs of your staff. It should be noted that if you are not a licensed mental health practitioner, you are not qualified to make diagnostic judgements about the mental health status of your staff. Plan to work with local mental health practitioners to help support staff. In the absence of a dedicated mental health team, the deployed ICS safety officer should be tasked with observing staff for mental health. Working closely with the jurisdiction's mental health services and providers will be important.

7. Alerts, Warnings, Notifications, and FEMA's Integrated Public Alert and Warning System (IPAWS)

7.1. Importance of Public Alerts, Warnings and Notifications (AWN)

In any emergency, adequate preparation, timely alerts, and actionable warnings assist residents of an affected community by providing critical safety messages to protect them. In the immediate aftermath of a nuclear detonation, instantaneous AWN is necessary to tell people in the affected area how to avoid death and injury from radiation. Development of significantly improved AWN capabilities, such as FEMA's IPAWS, is helping to mitigate hazards and lessen the impact of all disasters, including nuclear detonation. Planners have a critical role to ensure AWN guidance and procedures are documented so they can be applied, tested, and exercised. Awareness of the importance of AWN planning guidance related to nuclear detonation needs to be increased by prominently incorporating the key planning factors in this chapter into all plans, procedures, SOPs, and checklists related to nuclear detonation response.

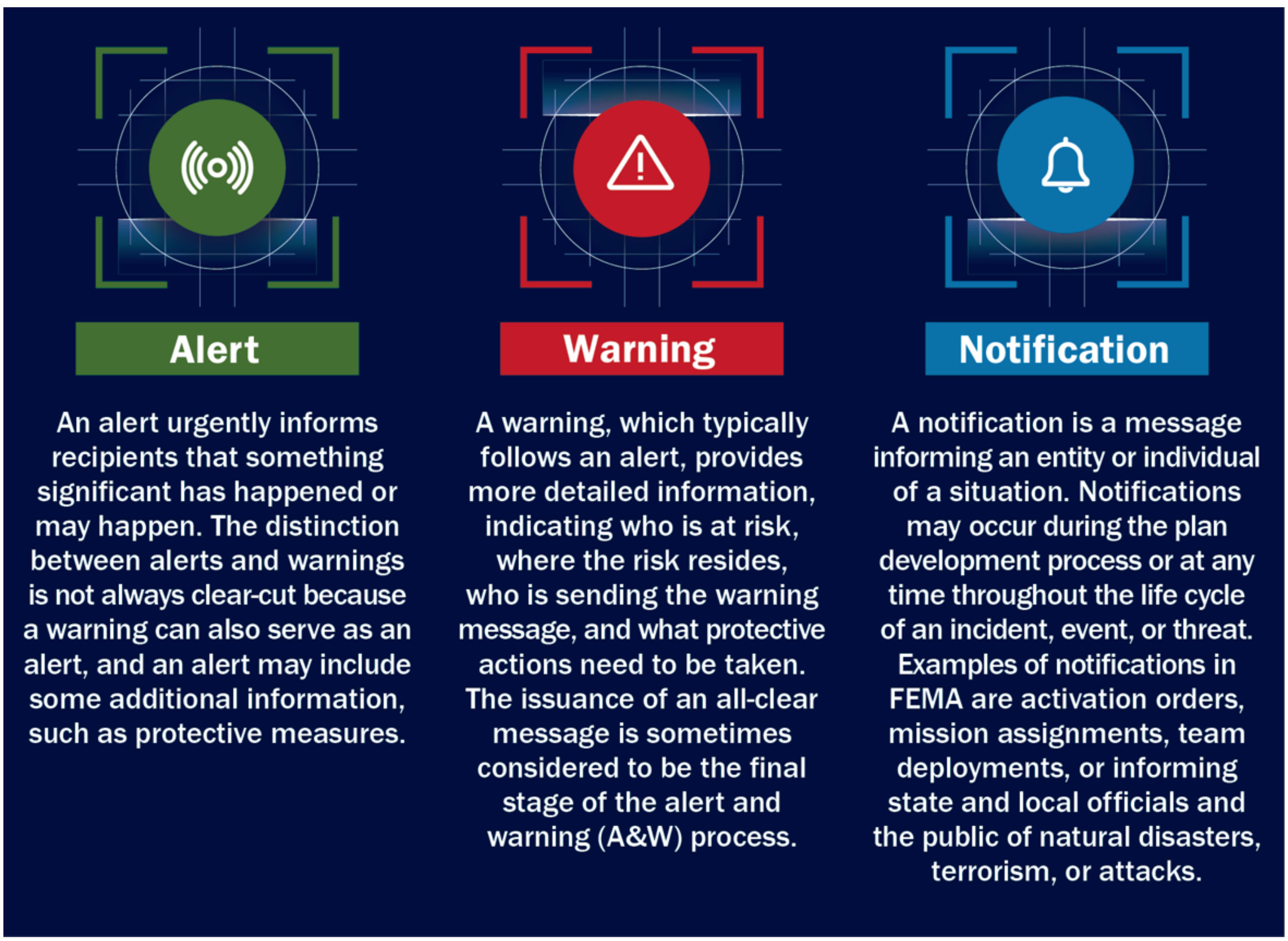


Figure 38: Alert, Warning, and Notification Definitions

Action Item

Planners must document, apply, test, and exercise AWN guidance for nuclear detonation incidents.

Coordination Opportunity

Planners must lead intergovernmental coordination of response communication plans, including FSLTT communications.

All disasters are local. As first responders are gearing up to respond to the initial effects of an incident, it is the responsibility of local officials having public alerting authority to rapidly and effectively communicate public actions to protect lives and property. This is especially important in a nuclear detonation situation having little or no warning when the federal response has not been activated. The widespread availability of public AWN capabilities is a critical element of FEMA's hazard and incident public communications activities.

Operational AWN planning is vital for the nuclear detonation situation. A dead zone of destroyed electrical grid, cell tower and internet outages will exist post-detonation. Anxiety about hazardous radiation will strongly affect the public, who will seek guidance on protective actions. The 2018 false missile alert in Hawaii showed the sensitivity of public messaging associated with a nuclear threat.

The adverse effects of a nuclear detonation on the means for public AWN makes it especially important for planners to proactively take them into account during the preparedness phase.[40] This new chapter has been added to include guidance regarding the possibility of advance warning and post-detonation scenarios that require functioning AWN capabilities to sustain public messaging, especially in the immediate aftermath.

The National Emergency Communications Plan (NECP) lists AWN among the four basic emergency communications functions. The purpose of AWN in the NECP is:

"Instructional messages directing protective actions to save lives and property, and convey time-sensitive information for preparation, response, and recovery-related services."

Refer To

NECP has guidance for the entire emergency communications ecosystem and specifies AWN functions, including incorporating diverse AWN technologies and interoperability: www.dhs.gov/xlibrary/assets/national_emergency_communications_plan.pdf

[40] This AWN guidance can also be considered regarding other releases of radioactive material that put the public at risk.

Planners are responsible for following guidance to ensure AWN tools can perform basic functions pre- and post-detonation. The "Get Inside, Stay Inside, and Stay Tuned" message works for both pre- and post-detonation. Continuing to send this message can be expected to prevent thousands of casualties from fallout exposure in large urban areas if provided in the first few hours (the earlier the better). Pre-detonation messaging can help prevent fallout exposure and reduce initial-effect casualties.

Action Item

Ensure all post-detonation AWN messaging includes"Get Inside, Stay Inside, Stay Tuned."

Other types of incidents require extremely rapid pre- or post-event shelter-in-place or evacuation orders, such as earthquakes, tsunamis, NPP emergencies, wildfires, flash floods or dam breaches, and hazardous material spills. The use of AWN guidance in this chapter is not limited to planning for a nuclear detonation.

In this regard, *A Guide to Public Alerts and Warnings for Dam and Levee Emergencies* is a particularly important and useful reference for nuclear detonation planners (US Army Corps of Engineers, 2019).

Coordination Opportunity

Coordinate with IPAWS program management officer (PMO) and other relevant authorities to enable IPAWS capabilities.

Information and guidance about public AWN are important because details about methods, timing, and other AWN factors are critical.For example, both planners and responders need to know the differences between mass notification using alert origination tools (AOTs) and the IPAWS platform that enables simultaneous dissemination of AWN by several channels using advanced communications interoperability technology. A careful review of recent media reports shows understanding the difference is paramount to saving lives when seconds matter.

Coordination Opportunity

Coordinate with other state and local authorities in your area, such as emergency management agencies, fire and police stations, military bases, universities, hospitals, and NPPs.

Refer To

The Community Lifelines Implementation Toolkit explains the seven different lifelines and their subcomponents, highlighting key infrastructure to consider during emergency response: www.fema.gov/sites/default/files/2020-05/CommunityLifelinesToolkit2.0v2.pdf

7.2. Public Alerting Authorities

The ICS provides a standardized approach to incident management that enables efficient functional integration into an effective response organization. Because public AWN is an essential element for meeting emergency information needs, it is an important factor in the ICS. Issuance of authoritative public AWN is among the key staff functions of an EOC, according to the Response Federal Interagency Operational Plan (FIOP). In discussing delivery of the Operational Coordination Core Capability, the FIOP describes SLTT and insular area governments as "functioning and operating from their designated emergency operations centers." These EOCs receive guidance from elected or appointed officials at all levels who have authority and responsibility to decide many issues, including public AWN. Insufficient attention to AWN in an EOC is risky.

Refer To

ICS is a command framework for incident response: www.fema.gov/sites/default/files/2020-07/fema_nims_doctrine-2017.pdf.

A jurisdiction's EOC is typically designated as the official alerting authority under the emergency manager or higher authority to issue public AWN. Designated EOC staff who are authorized to operate AOT software receive special training. Issuing public AWN is a challenge, partly because there is not always timely feedback on public responses. Public AWNs must be issued on time and by credible sources to persuade the public to act and follow instructions; save lives; and protect property.

Coordination Opportunity

To carry out their AWN mission, EOCs must coordinate effectively with a variety of guiding authorities during emergencies.

There are nearly 6,000 state and local EOC public alert initiators, and the AWN ecosystem continues to grow (U.S. Department of Homeland Security, 2021). Nearly 1,600 IPAWS alerting authorities are active nationwide and in U.S. territories, and their rate of increase is growing.

By Federal Communications Commission (FCC) regulation, only IPAWS alerting authorities are capable of sending WEA to commercial mobile devices without subscription.

Public alerting authorities need to draw on Annex N of the ESF-15 SOP in developing and exercising short, pre-scripted messages in addition to "Get Inside, Stay Inside, Stay Tuned." They must be prepared to very quickly send alerts before a nuclear detonation and in the immediate aftermath. Surviving alerting authorities must also be prepared to continue public messaging of fallout and other hazards as described in Chapter 6 and elsewhere in this guidance.

Refer To

ESF-15 is the external affairs annex to the FIOPs: www.fema.gov/sites/default/files/2020-07/fema_ESF_15_External-Affairs.pdf

Planners focused on the response to a nuclear detonation, particularly in urban areas, must endeavor to ensure a minimum essential non-subscription WEA capability can survive to provide immediate public AWN after a nuclear detonation. Although the internet is required to send a WEA, recent discussions with technical experts have indicated that it is prudent to send an alert and not assume that the internet is down across the entire country. WEAs are described in more detail below.

Action Item

Include WEA capabilities in AWN plans.

Subscription versus non-subscription public AWN for mobile devices is a complicated topic (Bean, 2019). After a nuclear detonation, there is no alternative to near-immediate public AWN for fallout warning and orders to shelter in place to save potentially thousands from the most dangerous initial radiation exposure.

Annex C of the *Response FIOP* also describes the roles and functions of JICs in coordinating public messaging. It also explains that the Secretary of Homeland Security may appoint ESF-15 deputies to affected states and regions to bolster coordination.

Action Item

Identify the number of IPAWs alerting authorities needed in your urban planning area that could enable a post-detonation WEA alerting capability to remain operational in the immediate aftermath.

The foregoing points are included to highlight for planners the critical importance of maintaining some minimum essential means for originating AWN through multiple dissemination channels to sustain the ESF-15 mission in operation, without interruption in the immediate aftermath of a nuclear detonation. This requirement for resilient AWN capabilities includes both state and local JICs. Careful and comprehensive planning is necessary to meet critical public AWN needs.

7.3. Public A&W Systems for Mass Notification

This section describes in general the types of AWN systems in use because planners need to know the types and locations of all available alert dissemination channels in order to be able to use those outside the nuclear detonation damage zones immediately, pre- and post-detonation.

Senior leader decisions and other messaging frequently needs to be rapidly communicated to the public via AOT. AOT refers to software used in EOCs to issue public AWN.

7.3.1. LOCAL JURISDICTION EMERGENCY NOTIFICATION SYSTEMS

The characteristic types of mass notifications include text messages,social media, emails, and reverse dial-back systems. The latter can be based on public databases, subscriptions, or both. These systems have varying degrees of capability for multiple languages, media types, and special features. AOTs generate the following kinds of mass notifications:

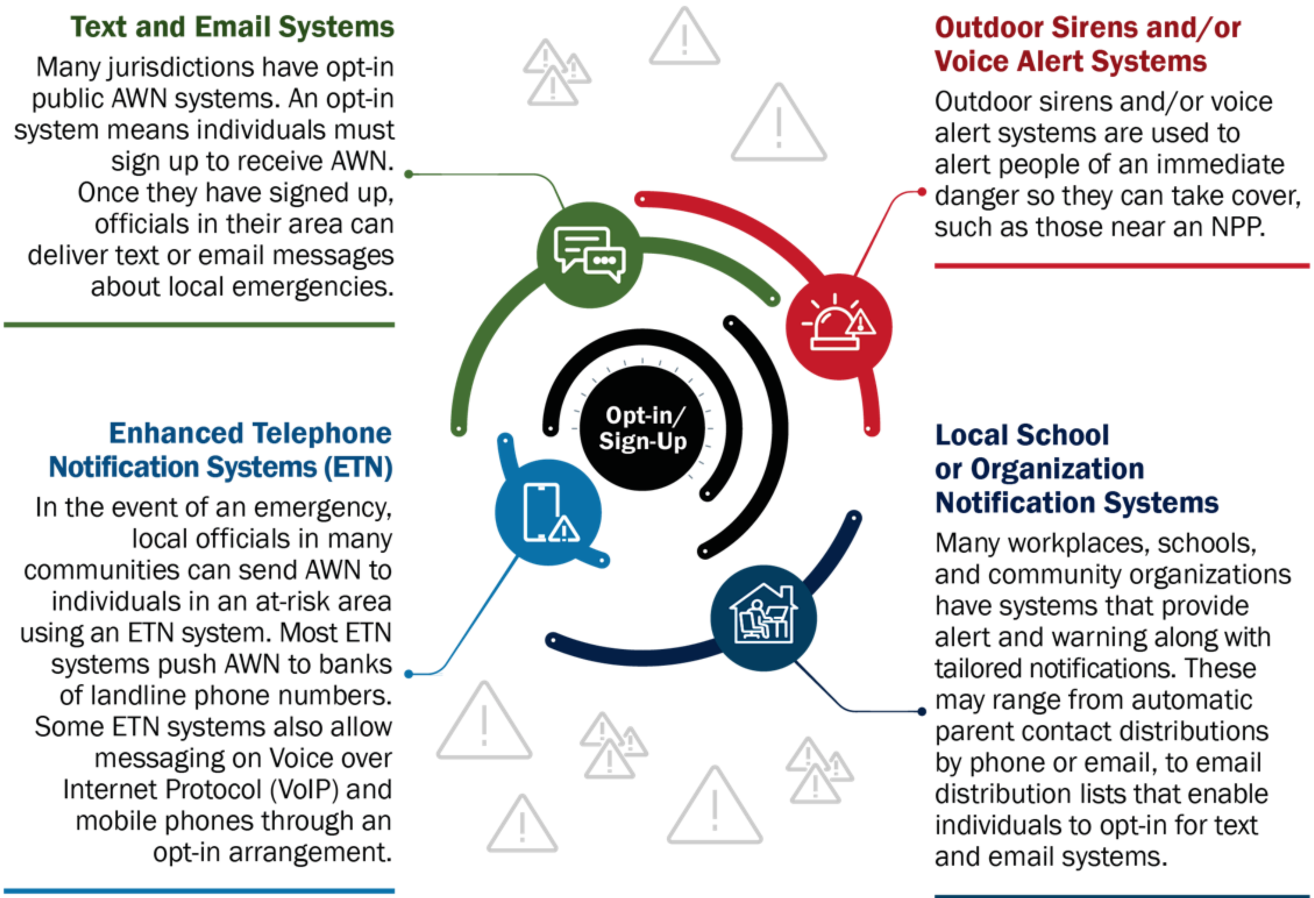


Figure 39: There may be pre-existing opt-in/sign-up AWN systems in local jurisdictions.

> **What Would You Do?**
>
> If you have a siren system, how often is it tested? What factors should be considered to determine a siren's resiliency in a nuclear detonation scenario?

7.3.2. EFFECTS OF DELAYS IN ALERTS, WARNINGS, AND NOTIFICATIONS

Pre-incident alert and warning preparedness planning needs to be informed by keen awareness of the existence of delays in the issuance of alerts, and that the effect of such delays is additive (Figure 40). This awareness is needed throughout the ICS, and particularly among EOC supervisors and staff members. Readiness training of individuals who are alert originators[41] needs to promote this awareness. Delays, and their additive effects, need to be removed or mitigated wherever possible. Results of tests, training, and exercises need to be tracked and applied toward certification, specialization, or qualification for a position such as public warning specialist or a similar position of AWN subject matter expertise.

Figure 40: Effects of Delays in Alerts and Warnings (derived from Mileti, 2019)

Timely responses are important for all AWN and are especially urgent in nuclear detonation scenarios. Many planners have received recommendations to prepare pre-scripted messages and to have them saved to their desktops. Caution is needed because on occasion, the AOT software or dissemination platform requires sending the message within prescribed times (i.e., within a certain number of minutes) after the alert has been prepared.

7.4. Integrated Public Alert and Warning System (IPAWS) Components

7.4.1. INTRODUCTION TO IPAWS

The IPAWS is a national A&W infrastructure available for use by FSLTT public alerting authorities to send emergency alerts to citizens. The Integrated Public Alert and Warning System Open Platform for Emergency Networks (IPAWS-OPEN) receives and authenticates messages transmitted by alerting authorities. IPAWS-OPEN then routes the messages to IPAWS communications pathways. IPAWS-OPEN transitioned to cloud provider facilities in April 2021. The IPAWS PMO works to provide alerting authorities with the advanced technologies, capabilities, and resiliency that IPAWS offers. FSLTT alerting authorities may choose to integrate local AWN systems that use Common Alerting Protocol (CAP)[42] standards with the IPAWS infrastructure. IPAWS provides public safety officials a gateway to send A&W messages to the public using the Emergency Alert System (EAS), WEA, National Oceanic and Atmospheric Administration (NOAA) Weather Radio All Hazards (NWR), and other public alerting systems, all from a single interface. A memorandum of agreement (MOA) with FEMA is required, and there are technical requirements for an alert authority to connect with IPAWS-OPEN but no fee. Figure 41 depicts the IPAWS architecture, including the CAP

[41] This phrase usually refers to the person operating an alert origination tool that sends an AWN.

[42] CAP is an Extensible Markup Language (XML) standard adopted by the Organization for the Advancement of Structured Information Standards (OASIS), the international standards-making body.

standards-based interoperability that enables dissimilar alert originators to select multiple alert distribution channels to meet specific needs.

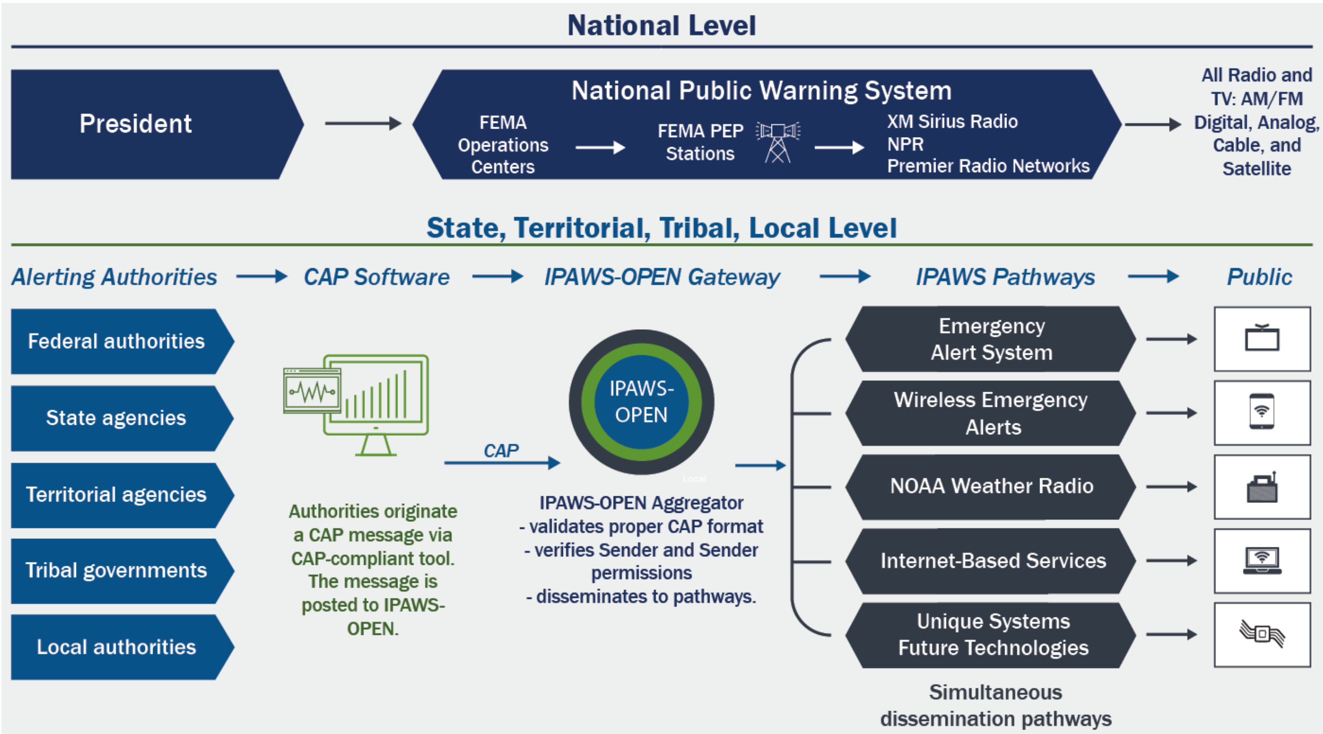


Figure 41: IPAWS-OPEN and National Public Warning System (NPWS) Architecture

Executive Order (EO) 13407 signed in June 2006 is the fundamental guidance. PL 114-143,the IPAWS Modernization Act of 2015 directed FEMA to:

1. Establish common alerting and warning protocols, standards, terminology, and operating procedures for the system;
2. Include the capability to adapt the distribution and content of communications on the basis of geographic location, risks, and multiple communication technologies;
3. Alert, warn, and provide equivalent information to individuals with disabilities, access and functional needs, or limited English proficiency; and
4. Ensure that specified training, tests, and exercises for such system are conducted and that the system is resilient, secure, and can withstand external attacks.

These important capabilities are operational and available for planners to incorporate into their urban area nuclear detonation response plans.

Refer To

EO13407 and Public Law (PL) 114- 143 contain basic IPAWS guidance: www.congress.gov/114/plaws/publ143/PLAW-114publ143.pdf

The 2020 National Defense Authorization Act (NDAA), PL 116-92 states that the authority to originate an alert warning the public of a missile launch directed against a state using the public A&W system shall reside primarily with the Federal Government. This law includes information sent to State Warning Points (SWPs) through National Warning System (NAWAS). FEMA has begun work on obtaining funding and recommended approaches to implement the provisions of PL-116-92.

Implementing the first two laws has enabled FEMA to better coordinate among state authorities and hundreds of localities based on common protocols and language across jurisdictions. Planners of response to a nuclear detonation need to know and carefully analyze the locations of all EOCs in their area of focus; especially the capabilities of their AOTs, including specifically each IPAWS Alerting Authority. The AWN planning goal must be to sustain the survivability of at least one EOC within the planning area to ensure public AWN messaging in the immediate aftermath of a nuclear detonation.

Action Item

Create a comprehensive list of each EOC's AWN capabilities and IPAWS alerting authorities in your urban planning area.

Emergency management and public safety officials should take full advantage of IPAWS' capabilities. IPAWS alerting authorities are encouraged to regularly conduct more than the minimum required AWN training and testing; and to seek out opportunities to participate in exercises that include issuing practice alerts. Each IPAWS Alerting Authority is required, based on its memorandum of agreement with FEMA, to:

> "...demonstrate their ability to compose and send a message through the IPAWS-OPEN system at regular intervals. Such demonstration must be performed on a monthly basis through generation of a message successfully sent through the IPAWS-OPEN Training and Demonstration environment." (FEMA, 2021b)

IPAWS includes two primary components, the IPAWS-OPEN and the National Public Warning System (NPWS) as shown in Figure 41.

Use of the CAP standards-based interoperability also enables industry partners to develop content and/or devices that can be used by individuals with disabilities, access needs, and functional needs to receive emergency alerts. CAP alerts can transport rich multimedia attachments and links in alert messages. The IPAWS PMO participates in operational testing and evaluation of products and is continually working toward integrating additional technologies and encouraging industry or private sector innovation to meet the needs of the whole community.

IPAWS alerting authorities that fail to demonstrate their proficiency in the IPAWS Lab for three consecutive months will lose access to the IPAWS Live environment and will not be permitted to send alerts through IPAWS. It is imperative that public confidence in our A&W systems remain high and that the information provided to the public is always clear, authoritative, and trusted.

7.4.2. NATIONAL PUBLIC WARNING SYSTEM COMPONENT

EO 13407 provides, among other things, the authority and operational framework for IPAWS along with a mandate that the EAS is to be administered as a critical component. The Primary Entry Point (PEP) stations are a key element of the EAS defined by the FCC rules requiring all NPWS, cable television systems, wireless cable systems, satellite digital audio radio service (SDARS) providers, and direct broadcast satellite (DBS) providers to receive and immediately re-broadcast a Presidential warning message in the event of a national emergency. EAS-participating radio and television providers nationwide are the stewards of this important public service in close partnership with alerting officials at all levels of government.[43] NPWS, also known as the PEP stations, consists of private or commercial radio broadcast stations that cooperatively participate with FEMA to provide emergency A&W information to the public before, during, and after incidents and disasters (Figure 41). The FEMA NPWS PEP stations serve as the primary source of initial broadcast for a national (Presidential) alert, as discussed below, specifically regarding nuclear attack warning (FEMA, 2016b). NPWS stations are equipped with backup communications equipment and power generators designed to enable them to continue broadcasting information to the public during and after an incident. The IPAWS PMO has expanded the number of participating broadcast stations across the nation to directly cover more than 90% of the U.S. population. Secure satellite communications are fully integrated with NPWS to provide a reliable, redundant communications system that ensures delivery of national emergency AWN but does not rely on connection to the internet.

Coordination Opportunity

- IPAWS alerting authorities' test verifications are opportunities to collaborate with local broadcasters.
- The NPWS PEP station network exemplifies private and commercial sector coordination with federal entities.
- Leverage mutual aid or assistance agreements to provide redundancy and resiliency of AWN capabilities following a nuclear detonation.

7.4.3. INTEGRATED PUBLIC ALERT AND WARNING SYSTEM OPEN PLATFORM FOR EMERGENCY NETWORKS (IPAWS-OPEN COMPONENT)

Emergency Alert System (EAS)

The EAS is the backbone of national A&W. Due to its resiliency, the EAS is expected to operate when other communication pathways are not in operation. It reaches more people in more places from a single alert origination and can provide highly detailed emergency AWN. EAS is extremely valuable in rural communities

[43] The EAS includes the NPWS PEP stations along with all radio and television broadcasters, cable television, wireless cable systems, SDARS and DBS providers.

and is very important in urban area nuclear detonation and other post-disaster situations. NOAA's NWR, along with SLTT governments, use the EAS regularly.

IPAWS-OPEN collects CAP alerts issued by authorized public officials and distributes them to EAS participants, either over the internet or by over-the-air broadcast. EAS participants are required by the FCC to monitor both systems for redundancy and, in accordance with state EAS plans, to monitor other radio/television station sources. EAS participants require an internet connection to poll IPAWS-OPEN.

An audio announcement and text display interrupts programming, including on TVs and radios. Emergency messages sent via IPAWS to EAS can support full message text for screen crawl/display, audio attachments such as MP3, and additional languages as determined by local broadcast stations.

Local coordination and partnership are needed because broadcast stations are not required to air local emergency messages. EAS activation interrupts programing once only. The emergency message audio and text are repeated twice—then regular programming continues. The television display format for EAS varies from station to station.

Coordination Opportunity

Collaboration with EAS radio stations is necessary to enable local EAS alerting.

Some question the effectiveness of AM/FM radio and satellite radio as channels for disseminating AWN—particularly in comparison to digital media. Others point out that 2019 research data from Nielsen and other sources suggests that radio continues to be an important mode of communications to the public (Westwood One, 2019). Research data in 2019 showed more than 90% of all Americans are reached every week by radio. Time spent listening (TSL) to AM/FM radio is 10 times greater than TSL to streaming platforms and it reaches 60% in connected cars. Total AM/FM listeners reached 250 million in 2018. Caution is needed to avoid exaggeration of access provided by AM/FM radio for purposes of AWN. The devastation and communications disruptions following a nuclear detonation can reasonably be expected to provide incentive for greater use of radios in cars and trucks to seek emergency AWN broadcasts.

What Would You Do?

Do you think it is likely that you, personally, would receive an emergency message broadcast on the radio? How would this vary for different populations in your community?

Planners for urban area response to a low-altitude (~5km above ground level or lower) nuclear detonation should follow the current technical assessment that "Individual radios outside the moderate damage zone (at time of detonation) are unlikely to be affected" by SREMP (Lawrence Livermore National Lab [LLNL], 2019).

A nuclear detonation will destroy and damage elements of the electrical grid and the communications infrastructure; this can be expected to result in overload of the communications assets that remain operational. The *2010 Planning Guidance* stated that "Radio broadcasts may be the most effective means to reach the people closest to and directly downwind from the nuclear explosion." Because this observation remains essentially correct, and gaps in internet connectivity can be expected, planners need to pay particular attention to the resiliency of EAS and the potential for AM/FM radio and television surviving the nuclear detonationto fill or mitigate gaps in coverage for public AWN.

Action Item

Include battery-powered AM/FM radios in nuclear detonation response plans to leverage radio availability in cars, trucks, homes, schools, and public buildings.

This is the "STAY TUNED" part of the quintessential nuclear detonation warning.

Planners and responders need to consult State Emergency Communications Committees (SECCs) and Local Area Emergency Communications Committees who are already responsible for maintaining their FCC-mandated EAS plan. Planners need to be aware of the need for public alerting authorities to originate a required weekly test (RWT) message through IPAWS for EAS distribution every week. This will verify their alerting software is currently able to send emergency AWN through the IPAWS Production or Live system.

Action Item

Ask the IPAWS PMO for PEP station information relevant to your urban area, such as locations, contact information,and capabilities.

Wireless Emergency Alerts (WEA)

WEAs are emergency messages from authorized public IPAWS alerting authorities that can be broadcast from cell towers to any WEA-enabled mobile device in a locally targeted area.[44]

By federal law and FCC rules, only alerting authorities having an MOU with FEMA and IPAWS-compliant CAP AOTs (Figure 41) are capable of sending WEAs. Use of the CAP standard-based interoperability also enables industry partners to develop content and/or devices that can be used by individuals with disabilities, access needs, and functional needs to receive WEAs.

Action Item

Ensure your planning area has an MOU with FEMA and IPAWs-compliant tools to send WEAs.

[44] Detailed rules for WEA have been published by the FCC in 47 Code of Federal Regulations (CFR) Part 10.

The capability to disseminate non-subscription public warning via WEA to all locally geo-targeted mobile devices to “Get Inside, Stay Inside, Stay Tuned” pre-detonation (if tip-off is provided), during the immediate aftermath, and continuing during shelter in place, evacuation, and fallout plume movements significantly improves the odds for survival and damage limitation for the affected population. Thus, planners need a method to ensure that a minimum essential number of IPAWS alerting authorities remain operating in the immediate aftermath at EOCs in or near their planning area. This includes determining where to locate additional EOCs with IPAWS alerting authorities to enhance AWN resiliency. Planners also need to analyze the effects of cell tower attrition degrading cellphone/mobile device coverage. They also need to plan ahead to ensure resilient alternative transport mechanisms and connectivity for their EOCs in general and for alert originating tools in particular.

Action Item

Identify the number of IPAWs alerting authorities needed in your urban planning area that could enable a post–nuclear detonation WEA alerting capability to remain operational in the immediate aftermath.

Planners need to leverage IPAWS’ advanced AWN interoperability technology by identifying exactly how many IPAWS alerting authorities should be established among EOCs in their planning areas. By establishing redundant IPAWS-capable EOCs, at least one EOC with an IPAWS WEA alerting capability should survive a nuclear detonation and remain operational in the immediate aftermath to broadcast, “Get Inside, Stay Inside, Stay Tuned.”

IPAWS PMO has released software that supports the following significant FCC-mandated WEA enhancements:

- 360-character alerts
- Spanish-language alerts
- WEA Test category and Public Safety category
- Reach 100% of the target area with no more than 1/10th mile overshoot

These enhancements also require updates to wireless providers’ nationwide networks, customer phones, and to AOT software that alerting authorities use to send alerts.

The IPAWS PMO has tested and confirmed that wireless providers can receive enhanced WEA messages from IPAWS-OPEN. But achieving nationwide availability for customers to receive enhanced WEA on their phones and devices across all cell networks is gradual. Most of the software used by IPAWS alerting authorities has been upgraded and tested by the IPAWS PMO. It is also a gradual process for all alerting authorities to become ready to write alerts that fully use all the enhanced WEA message content.

Refer To

IPAWS PMO makes many resources available to help partners and public officials. Downloadable videos and training materials are available at www.fema.gov/ipaws.

WEAs automatically display on the mobile device screen. WEAs can include a URL/web link, enabling recipients to promptly access more detailed information. WEAs use a unique ring tone and vibration, designed to draw attention and alert people to an emergency. The unique vibration, which distinguishes the alert from a regular text message, is particularly helpful to people with hearing disabilities. WEAs in the alert categories of Presidential, America's Missing: Broadcast Emergency Response (AMBER), and Imminent Threat can be sent, in addition to the two new alert categories mentioned above—WEA Test and Public Safety.

WEAs are targeted to the specific geographic area of the emergency. If a WEA-capable mobile device is physically located in that specific area, it will automatically receive and display the message. WEAs are true location-based alerting because alerts are sent to all phones in a cell tower's coverage area. These alerts are not sent to a database of phone numbers.

WEAs are not subscription based. Customers of participating wireless carriers with WEA-capable phones do not sign up to receive the alerts, nor does any app need to be downloaded. No tracking, delivery information, or status feedback is involved with WEAs.

Customers automatically receive WEAs if one is active in the area where they are located. Wireless customers are not charged for the delivery of WEA messages. Cellphones are delivered opted-in to receive WEAs, but the opt-in setting can be turned off in the settings of individual handset users.

IPAWS' WEAs use SMS-CB, a one-to-many service that simultaneously delivers messages to multiple recipients in a specified area. By using SMS-CB as the delivery service technology, WEAs avoid mobile device congestion issues experienced by traditional voice and text messaging SMS-PP alerting services. This translates into faster and more comprehensive delivery of messages during times of emergency.

By federal law and regulation, WEAs are received on mobile devices without subscription.

The type of mobile device affects how a recipient sees or receives WEAs. All major U.S. wireless providers are participating in WEA on a voluntary basis. Wireless carriers are selling mobile devices with WEA capability included; however, not all handsets on the market are capable of receiving WEAs. To find out if their mobile device is capable of receiving WEAs, users need to check with their wireless provider.

A key differentiator of the WEA versus existing subscription-based text messaging alert services is that WEAs enable alerts to be broadcast to any WEA-capable cellphone within range of a targeted cell communications tower, reaching 100% of the target area with no more than 1/10th mile overshoot.

NOAA NWR

When complete, National Weather Service's development of its interface with IPAWS-OPEN will activate IPAWS' NOAA weather radio distribution pathway shown in Figure 41.

NWR is provided as a public service. It includes more than 1,000 narrow band transmitters dispersed to provide coverage throughout all 50 states, adjacent coastal waters, Puerto Rico, the U.S. Virgin Islands, and the U.S. Pacific Territories. NWR requires a special radio receiver or scanner capable of picking up the signal. Broadcasts are found in the very high frequency (VHF) public service band at these seven frequencies (MHz):

Table 7: Public Service Band Frequencies (MHz)

162.400	162.425	162.450	162.475	162.500	162.525	162.550

This nationwide network owned by the Department of Commerce (DOC)/NOAA broadcasts continuous weather information directly from the nearest National Weather Service office. NWR broadcasts official Weather Service warnings, watches, forecasts, and other hazard information 24 hours a day, seven days a week to public and private receivers, including institutions such as schools and hospitals that are tuned in for continuous monitoring. The NWR broadcast can wake up radios during the night.

Working with the FCC's EAS, NOAA also maintains All-Hazards Emergency Message Collection System (HazCollect), which is used to broadcast Non-Weather Emergency Messages (NWEM) over the same vast nationwide network. In conjunction with federal, state, and local emergency managers and other public officials, NWR broadcasts warning and post-event information for all types of hazards, including natural (such as earthquakes, tsunamis, or avalanches), environmental (such as chemical releases or oil spills), and public safety (such as AMBER alerts or 911 Telephone outages). The *Response FIOP* states:

> "During an emergency, NWS forecasters interrupt routine weather programming and send out a special tone that activates weather radios in the listening area. Weather radios equipped with a special alarm tone feature can sound an alert and give immediate information about a life-threatening situation."[41]

Also, when the NAWAS Attack Warning is received at NWS offices, the warning will be broadcast as an NWEM over NWR and NOAA's Weather Wire Service (FEMA, 2016a).

IPAWS All-Hazards Information Feed to the Internet

Internet web services and applications may complete a MOA with FEMA's IPAWS PMO, allowing them to access, monitor, and retrieve public alerts in CAP format from the IPAWS Public Alerts Feed (Figure 41). When organizations and members of the general public then subscribe to the third-party internet web services and applications that have MOAs with IPAWS, these subscribers receive public AWN that have been issued through IPAWS-OPEN. More than 90 private companies pull the IPAWS Public Alerts feed for redistribution of alerts to signage, electronic message boards, smart home systems, speakers, sirens, desktops, and mobile applications, and substantial growth in the numbers and types of internet connections is anticipated. Figure 42 is an example of a smart kiosk that displays WEAs at street level. This kiosk is a product of IKE Smart City, an IPAWS All-Hazards Information Feed redistributor.

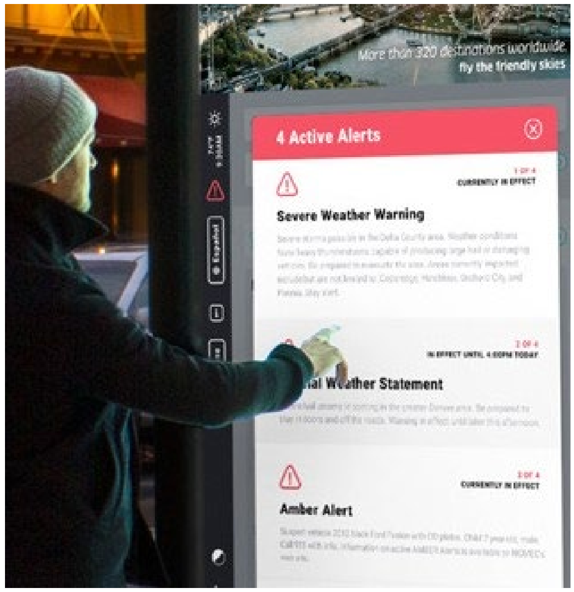


Figure 42: A Smart Kiosk Displaying WEAs

Planners responsible for urban area nuclear detonation response need to be aware if this distribution of all-hazards AWN is occurring among the jurisdictions in their planning area and take it into account in response planning.

Action Item

Ensure multiple EOCs in your jurisdiction have redundant IPAWS-OPEN connectivity.

Collaborative Development With IPAWS

Many private vendor companies in the AOT market are working to design IPAWS-compliant alert or ignition software and other IPAWS-compatible products that can distribute AWN to the public. Such systems include an IPAWS option or plug-in. As mentioned, much of the infrastructure needed to accomplish the IPAWS mission is owned and operated by the private sector. More than 20 alert origination software provider (AOSP) vendor companies have successfully demonstrated their IPAWS capabilities and compatibility; these numbers are also growing.

AOSPs are developers in both the private and public sectors that furnish software interfaces thatalerting authorities use to generate CAP messages. The software then delivers those messages to IPAWS-OPEN for dissemination to the public. Private-sector developers' interests vary among different aspects of IPAWS.

More than 130 private sector A&W system non-vendor organizations, plus more than 20 developers of public sector systems, have executed a MOA with FEMA for the purpose of gaining access to the IPAWS-OPEN test environment. Developers work in various public alerting and other functional categories. FEMA does not independently verify developer-submitted data. The IPAWS PMO cannot endorse any vendor products or tools, but it can provide stakeholders the opportunity to view demonstrations of tools and ask follow-up technical or operational questions.

Planners of nuclear detonation response should monitor ongoing public and private sector IPAWS programming developments and identify opportunities that can be leveraged to improve AWN distribution in their jurisdictions.

Becoming an IPAWS Alerting Authority

Any qualifying public safety organization recognized by appropriate FSLTT authorities may apply for authorization to use IPAWS to send alerts to the public. A prospective alerting authority must have a signed MOA in place with the IPAWS PMO before receiving access to leverage IPAWS capabilities. Once the MOA has been approved, a Collaborative Operating Group Identification (COG ID) and digital certificate will be generated and implemented in the IPAWS-OPEN system. A copy of the executed MOA, along with the COG ID and digital certificate, will then be provided to the sponsoring organization. A new IPAWS alerting authority must have a signed MOA with FEMA to enable use of IPAWS. Also, a COG ID and digital certificate will be implemented in IPAWS-OPEN and provided to the new IPAWS alerting authority along with a copy of the executed MOA.

> For a new IPAWS alerting authority, their COG ID and digital certificate must be implemented in the IPAWS-OPEN system before use.

Public safety organizations may apply to use IPAWS to exchange alert information with other IPAWS users with CAP-compatible origination software. Each organization that successfully applies to be an IPAWS user is designated as a COG. When the application steps have been successfully completed, the COG will be granted authority to send alerts to the public through IPAWS and the PMO will issue a certificate for testing and live operations. It is critical to note that these certificates do have expiration dates and alerting authorities should work with the PMO to ensure certificates are up to date. Public safety organizations need to contact their state's Office of Emergency Management before applying to IPAWS to ensure their state's policy permits the organization to act as an alerting authority; every state is different. Some states have rolled out the IPAWS alerting authority process differently from others, and some have changed their rollout process. When needs to establish IPAWS alert authorities have been identified by planners responsible for urban area nuclear detonation response, the planners need to become familiar with the COG rollout process both in their area and at their state level.

Refer To

Downloadable IPAWS videos and training materials are available at www.fema.gov/ipaws

The IPAWS PMO develops resources for public safety officials that are designed to encourage, assist, and enable partners to incorporate IPAWS into governance structures, strategies, policies, business models, and SOPs.

Results of tests, trainings, and exercises need to be tracked and applied toward certification, specialization, or qualification for a position such as Public Warning Specialist or a similar position of AWN subject matter expertise.

Coordination Opportunity

The IPAWS PMO collaborates with many private vendors to develop IPAWS-compatible AOTs.

7.5. Public Alerting, Warning and Notification in Operational Planning

Previous sections have described common public AWN methods and supporting platforms in use. A planning approach shared by many is to use multiple systems and platforms to ensure messages are clear and that the source and information content of all AWN public messaging can be trusted. Some of the most relevant guidance for pre- and post-detonation planning is the *Response FIOP*. It and the closely related *NRIA* include very important guidance for the federal interagency and SLTT planners.

Ensuring that nuclear detonation response plans are informed by this proven guidance will contribute substantially to public trust in AWN received during such catastrophic emergency. Additional federal guidance specific to AWN from the Community Lifelines' Communications Component, and its important relationship to ESF-15, is also discussed.

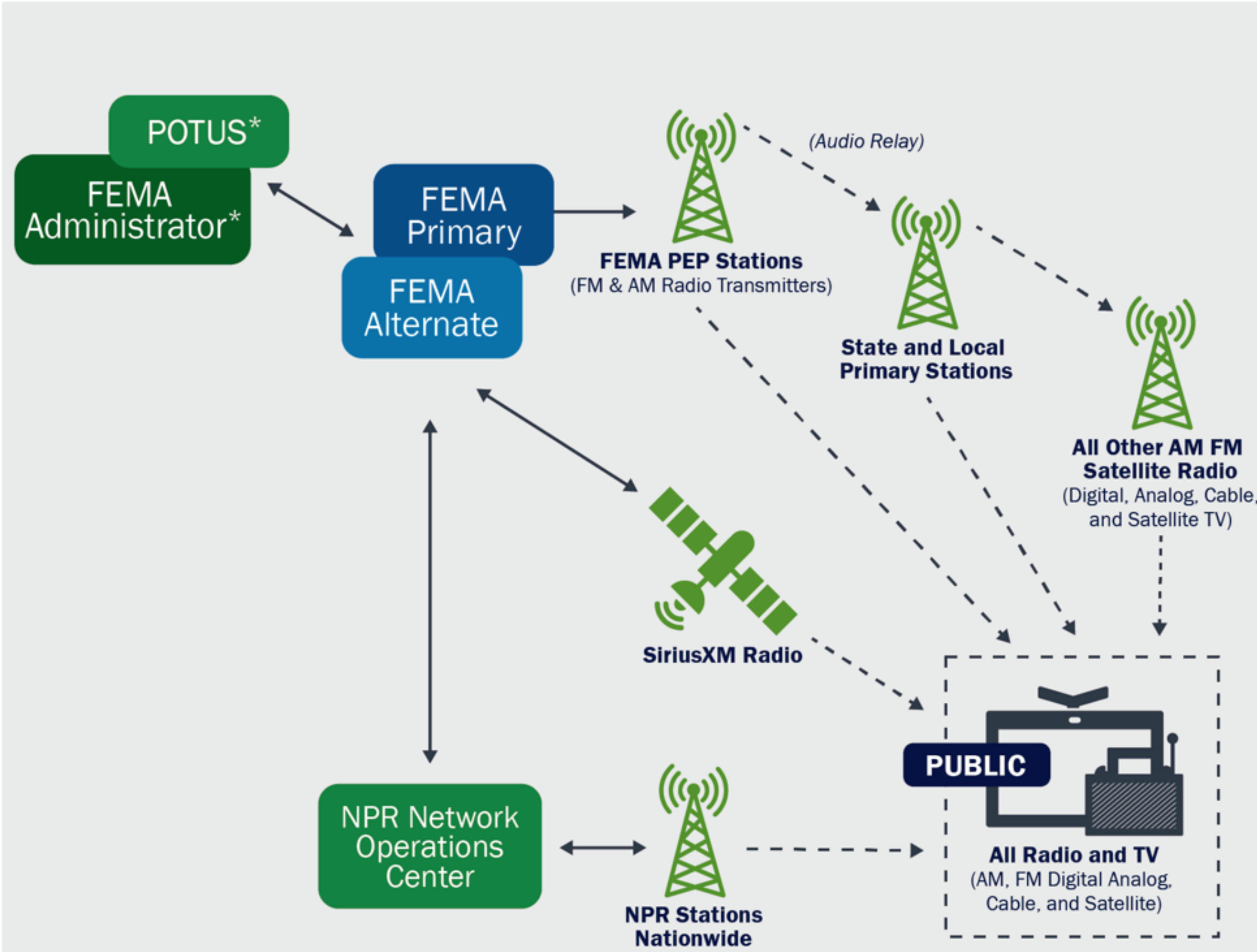
Refer To

Response Federal Interagency Operational Plan describes how federal agencies coordinate activities to respond to emergency incidents: www.fema.gov/sites/default/files/documents/fema_response-fiop.pdf.

7.5.1. PRESIDENTIAL TO PUBLIC ALERT—PRE-DETONATION SCENARIO

Warning of an attack would come via a NAWAS announcement from the FEMA Operations Center (FOC)/ FEMA Alternate Operations Center (FAOC). State-level issuance of WEA would be based on receiving a NAWAS alert from the FOC/FAOC. This section describes how NAWAS operates pre-detonation and how IPAWS and NAWAS operate post-detonation.

The *Response FIOP* outlines how a national-level EAS alert activated by the president reaches the public through the channels of FEMA-affiliated broadcast stations, SiriusXM satellite radio, and National Public Radio; that is, a President to Public Alert (FEMA, 2016b).



* FEMA may use either one or both of the IPAWS and the National Public Warning System (NPWS) to initiate a Presidential alert depending on the national emergency scenario. Alerts sent via the IPAWS may be directed for dissemination to Wireless Emergency Alerts (WEA), Emergency Alert System (EAS), or both, and to other alert dissemination systems that may be integrated into the IPAWS in the future, depending on the national emergency scenario. National alerts sent by FEMA shall include content in the alert to indicate whether the alert was originated from the President or the FEMA Administrator.

Figure 43: Delivery of Presidential Alert to the Public (derived from *Response FIOP*)

NAWAS delivers alerts via a continuous private line telephone network. In a pre-detonation scenario, the NAWAS Manual specifies that:

> "The national-level EAS is activated by an order from the President to the White House Communications Agency (WHCA) duty officer or the President's Communications Officer (PCO) through the FOC or FAOC. The FOC/FAOC authenticates the request and establishes the PEP conference. At the request of the President, FEMA distributes Presidential Level messages to the PEP stations." (LLNL, 2019)

Refer To

FEMA Manual 211-2-12 is an authoritative reference for FEMA public warning policy, attack alerts, EAS activation, and other alerts: www.hsdl.org/?abstract&did=843365

Many response planners are familiar with state and local EAS plans. These plans must be approved by the FCC as the regulatory body since the broadcast stations are privately owned. The FOC/FAOC controls NAWAS priorities, and the SWPs set priorities within their jurisdictions based on non-interference with national priorities. State and local governments routinely use the EAS to transmit critical information to the public, including NWS all hazards' alerts. These localized A&Ws are sent according to state and local EAS plans.

As mentioned, the 2020 National Defense Authorization Act, PL 116-92 states that the authority to originate an alert warning the public of a missile launch directed against a state using the public A&W system shall reside primarily with the Federal Government. This law includes information sent to SWP through NAWAS. FEMA has begun work on obtaining funding and recommended approaches to implement the provisions of PL 116-92.

Subsections below address AWN in relation to the pre- and post-nuclear detonation scenarios being considered throughout this planning guidance. The purposes of the following subsections include familiarization with important federal interagency guidance and describing how planners can properly apply the latest technical information about low-altitude nuclear weapon effects in the nuclear detonation scenarios to AWN requirements. This section ends with a discussion of approaches planners should take to ensure the use of multiple AWN pathways in anticipation of the post-detonation damage to critical infrastructure.

Refer To

"A Science-Based Tool for Emergency Planning" in the October/November 2018 issue of Lawrence Livermore National Lab's (LLNL's) periodical *Science and Technology Review:* str.llnl.gov/2018-10/alai

7.5.2. RESPONSE FIOP

The *Response FIOP* is a model for building an effective AWN program. Federal guidance specific to AWN exists in the *Response FIOP* and must not be overlooked.

Although disaster response is local, planners at all levels need to understand the *Response FIOP* to ensure their SLTT plans include information that enables their emergency managers to prepare for nuclear detonation scenarios. Familiarity with *Response FIOP* will help planners identify the source of nation-level messages and what to expect. It will also help them prepare their own well-informed and thoughtful messages, save these pre-scripted messages, and have them ready to send at a moment's notice.

Regional planning also needs serious consideration since some areas of the country now regard a regional response to a black sky disaster affecting multiple states and jurisdictions as the only practical response and the most realistic planning approach.

Black sky refers to the widespread and cascading infrastructure effects of a catastrophic incident, such as nuclear detonation, or similar incident, such as grid collapse.

In the *Response FIOP*, an Operational Coordination core capability annex is included as a means of supporting proper execution of the other Response core capabilities. This annex includes specific reference to AWN because it is a crosscutter that supports all Community Lifelines. AWN is deemed "essential for providing the public with lifesaving and life-sustaining information prior to, during, and following a catastrophic incident."[45] The *Response FIOP* is correct to emphasize that timely restoration of communications infrastructure is very important. However, it can be argued that advance identification and implementation of measures to sustain the operational capabilities of alert origination authorities ought to be very high priorities for planners, considering the unique effects of a nuclear detonation.

Action Item

Nuclear detonation response planning for AWN must be multi-jurisdictional.

Indeed, the *Response FIOP* continues:

> "Careful attention must be paid to survivability of the means to disseminate lifesaving messages required to protect survivors immediately following a nuclear detonation; or in advance provided adequate means of technical warning are employed."[46]

Urban area planners need to develop a methodology for determining where and how many alerting authorities are needed to sustain continuity and survivability of public AWN from nuclear detonation blast and other effects. This could include establishing additional IPAWS alerting authorities, enough to prevent (or strongly mitigate) loss of AWN capability (i.e., WEA and EAS).

Planners of response to a nuclear detonation should know and consider the locations of all EOCs and the capabilities of their AWN tools, including specifically each IPAWS alerting authority.

[45] *Response FIOP*, Annex C

[46] *Response FIOP*, Annex C, Appendix 1, "Communications Resources"

What Would You Do?

How can online sources in your planning area be collated to provide quick lookups of all EOCs and their AWN AOTs?

Plans and procedures are needed for alerting authorities in all EOCs in the urban area to rapidly regain situational awareness of others' operating status post-detonation.

IPAWS PMO is responsible for implementation of most of the provisions of the 2020 National Defense Authorization Act, PL 116-92. PL 116-92 requires, among other things, credentialing of all persons who originate alerts, establishing capabilities for immediate cancellation of sent alerts, and other provisions to improve operation of AOTs and alerting authorities in EOCs for more effective public AWN while avoiding mistakes.

Making specific reference to WEA, the *Response FIOP* notes the interface to mobile service providers that delivers AWN to "individual mobile devices located within the affected area" and calls out the "geographically targeted, text-like alerts to the public."[47]

Action Item

- Ensure AWN provisions in nuclear detonation plans comply with FIOPs.
- AWN plans must identify multiple messaging outlets to ensure resiliency and redundancy.
- Methodically determine how many alerting authorities are needed at each EOC to prevent loss of IPAWS capabilities.

The same approach—redundancy and resiliency—is guidance for FSLTT planning activities to ensure the ability of broadcast radio stations in the urban area to extend their signals to surviving receivers in damaged or denied areas. Examples are car and truck radios, many organizations such as hospitals, nursing homes, and other businesses that constantly monitor for alerts using NOAA emergency weather radios.

Action Item

Ensure pre- and post-incident AWN templates are available for alerting authorities.

For a nearby jurisdiction to provide AWN capabilities, to substitute damaged or destroyed capabilities, AWN must be included in their Emergency Management Assistance Compact (EMAC) or some comparable agreement. In addition, plans are needed for alerting authorities in EOCs in the urban area to regain

[47] Response FIOP, Annex C

situational awareness of operating status among area AWN entities. Guidance for situational awareness in the *Response FIOP* needs to be applied. Many technical variables need to be considered in a more rigorous analytical framework.

Action Item

Plans should include methods for EOCs/alerting authorities to attain information about surviving AWN capabilities post-detonation.

7.5.3. NUCLEAR/RADIOLOGICAL INCIDENT ANNEX (NRIA)

The *NRIA to the Response and Recovery FIOPs* also provides guidance for federal agency planning and a reference for state and local planners. It includes a public preparedness planning assumption applicable to a nuclear detonation in an urban area. This planning assumption makes explicit the need for survivable AWN capabilities pre- and post-detonation:

"Public education on protective actions and response activities prior to an IND attack and prompt messaging after an attack occurs will minimize the unnecessary loss of life. Failure to inform the public immediately after an attack will result in the unnecessary loss of life. Public messaging issued by local authorities immediately after the incident, instructing shelter in place for 12 to 24 hours and "Get Inside, Stay Inside, Stay Tuned" will be essential to saving and sustaining lives."[48]

Refer To

The *NRIA* provides specific federal guidance for nuclear detonation planning: www.fema.gov/sites/default/files/2020-07/fema_incident-annex_nuclear-radiological.pdf

The alert origination tools needed to deliver immediate lifesaving messaging are owned and operated by the states and localities. Planners need to consider approaches to ensure survivable AWN capabilities at the state and local levels.

The need to plan and implement, in advance, approaches to ensure survivable AWN capabilities can be met most effectively at the SLTT levels. Table 8, from the NRIA,[49] summarizes critical AWN considerations for planning.

[48] *NRIA*, Branch 1, page B1-25.

[49] *NRIA,* Branch 1 IND, Critical Considerations, page B1-7.

Table 8: Critical AWN Considerations for Nuclear Detonation Preparedness

Critical AWN Consideration	Significance in Urban Area Nuclear Detonation
Immediate Public Information	Survivable AWN capabilities needed to provide SA and protective actions.
Shelter-In-Place Messaging	In the first 60 minutes, most lives will be saved through messaging.
Situational Awareness	Enables avoid/mitigate initial and delayed radiation effects and other impacts.
SREMP	Grid lines will conduct damaging electric pulse outside blast area. Pulse rapidly declines to zero after the detonation. Permanent damage to electronics will generally be limited to within the MDZ from blast and EMP effects, although some isolated power surges can damage unprotected communications equipment plugged into wall sockets up to 9 miles away.
Devasted Infrastructure	Survivable messaging needed to reach battery-operated radios inside damage zones.
Simultaneous Mission Requirements	Need to maintain survivable dedicated emergency communications channels for AWNs.
Secondary Device Threats	Reinforces need for survivable AWNs.

Another key consideration regarding AWN prior to a nuclear detonation is the requirement to warn healthcare and other critical infrastructure sectors that they must disconnect from the electrical power grid and go on generators or other alternate electrical sources. See discussion of the pre-detonation scenario below.

Planners need to be aware of significant healthcare-related AWN capabilities that advance pre-detonation warning would enable to be leveraged. These include the CDC Health Alert Network (HAN), the HHS Technical Resources Assistance Center and Information Exchange (TRACIE), and state health department alert networks that are networked with CDC's HAN. The CDC's HAN is a "push" notification, and the HHS' TRACIE is an accessible resource.

TRACIE is a healthcare emergency preparedness information gateway that ensures all stakeholders at the FSLTT government levels; in NGOs; and in the private sector have access to information and resources to improve preparedness, response, recovery, and mitigation activities. The CDC Office of the Assistant Secretary for Preparedness and Response uses TRACIE to support timely access to information and promising practices, identify and remedy knowledge gaps, and provide users with responses to a range of requests for technical assistance.

7.6. Community Lifelines and Emergency Support Functions (ESFs)

Public AWN is an essential element of information under the Communications Component of Community Lifelines in the National Response Framework (NRF). Public AWN is a crosscutting Core Capability, a key element in decision-making, and a critical enabler for messaging fallout zones, evacuation orders, and shelter in place.

Refer To

NRF and NIMS contain overarching FEMA policy for all levels of response.

- www.fema.gov/emergency-managers/national-preparedness/frameworks/response
- www.fema.gov/emergency-managers/nims

Action Item

Ensure plans include consistent alert origination tests and exercises.

Planners need to mandate increases in the frequency of tests, trainings, and exercises for all individuals allowed to operate AOTs to ensure high levels of proficiency and thereby lessen or eliminate delays and false alerts that detract from public confidence. Planners must also ensure that proficiency in AWN for nuclear detonation scenarios is included in readiness training.

Sustaining AWN capabilities without interruption post-detonation enables state and local JICs, which become the leading sources of unified public information.

Refer To

Annex N - Radiological of *FEMA's ESF-15 SOP* prescribes AWN and other public messaging actions in response to nuclear detonation: www.fema.gov/sites/default/files/2020-10/fema_esf-15_sop_2019.pdf

Action Item

Training and proficiency validation are critical to ensure rapid AWN delivery.

Community Lifelines have not replaced ESFs. The availability of IPAWS-OPEN depends on internet connectivity with the planning area hit by a nuclear detonation and what remaining infrastructure and EOC's/alerting authorities remain operational. Community Lifelines communications status reporting includes the electrical power grid, cellphone towers, broadcast towers, mobile communication systems, satellite networks, the internet, other networks, and regional, state, and local partners who have an agreement in place with leadership or EOCs in the area affected by the nuclear detonation.

Another key federal interagency planning guidance document that explicitly pertains to AWN is the ESF-15 SOP. Among many other significant provisions, Annex N of this SOP emphasizes the critical need to immediately save thousands of lives by avoiding exposure to decay of the most life-threatening radioactive fallout. It requires that all messaging must contain, “Get Inside, Stay Inside, Stay Tuned” until the fallout threat picture can be clarified (DHS, 2019).

7.7. AWN Planning Factors for a Low-Altitude Nuclear Detonation

7.7.1. SREMP

Low-altitude detonations have a significantly smaller area of EMP impact compared to HEMP or GMD impacts. Low-altitude EMP effects are generally associated with the SREMP and affect a much more limited area. More information on these effects can be found in Chapter 1 and Appendix 1.1: Electromagnetic Pulse (EMP), High-Altitude EMP (HEMP), and Geometric Disturbance (GMD).

7.7.2. RESILIENCY FACTORS

The most important resiliency element is backup power. There will likely be regional power outages after a nuclear detonation. Although actual damage to power systems and their substations will likely be within 12 miles of the detonation, the power grid may destabilize and cause regional power outages. However, like many other natural disasters that cause power outages, the power systems will likely begin to restore power within minutes or hours in outlying, undamaged areas.

Resiliency measures for this issue would be backup power (e.g., a generator) for systems that can tolerate a few minutes of power outage; and an uninterruptible power supply (UPS). The UPS could be either an online/double-conversion type or a high-quality line interactive type for systems that can be afforded little or no down time.

Level 1: Basic, cost-effective protective measures

There are several low-cost methods and best practices to greatly improve the likelihood that equipment will function after the detonation. These measures are appropriate for most systems and improve the likelihood of desired continued operation outside of immediate damage areas (greater than 5 miles).

These measures include:

- [When warned] Unplug power, data, and antenna lines from spare equipment where feasible.
- [When warned] Turn off equipment that cannot be unplugged and is not actively being used.
- Using at least a lightning rated surge protection device (SPD) on power cords, antenna lines, and data cables; maintain spare SPDs.
- Grounding of equipment wherever possible.

Level 2: Enhanced electronic equipment protection

To greatly improve the likelihood of continued operation and to protect electronic equipment in the vicinity of a detonation from EMP illumination and line coupled voltage/current surge, use fast-acting, EMP-capable filters and surge arresters on power cords, antenna lines, and data cables. Also, install fiber optics and ferrites,[50] where possible, to protect critical equipment inside exposed facilities. Within 5 miles, significant blast damage should also be expected and capability survival depends not only on EMP protection for electronics, but also on building integrity. In addition to the level 1 recommendations, consider:

- Using fast-acting, EMP-rated SPDs on power cords, antenna lines, and data cables to protect critical equipment.
- Using fiber optic cables (with no metal); otherwise use shielded cables, ferrites, and SPDs.

> Shielded racks, rooms, or facilities may be more cost-effective than hardening numerous cables. Additional protection may be appropriate for systems expected to operate after a HEMP or GMD incident; however, that is beyond the scope of this guidance.

7.8. Planning in Post-Detonation Scenarios

Post-detonation, the AWN planning goal is to sustain capabilities to continue AWN messaging when key infrastructure elements have been destroyed or degraded by a nuclear detonation.

According to the NAWAS Manual, North American Aerospace Defense Command (NORAD)/US Northern Command (USNORTHCOMM) and SWPs are responsible for reporting trans-attack[51] and post-attack nuclear detonations to the FOC/FAOC in the form of flash nuclear detonation reports and other types of extremely urgent reports because locations must be known before responders can begin work. AWN can be sent to affected areas based on immediate analysis of technical factors (i.e., fallout wind vectors, forecast plots) described elsewhere in this document. The initial flash nuclear detonation report that states “transmit over NAWAS only” includes the area hit and the time, unless more details are available immediately. Local-origin flash nuclear detonation reports need to be sent to the SWP for relay to the FOC/FAOC.

Once a nuclear detonation has occurred, AWN takes on a new mission to continuously provide critical information to the public through the Recovery phase.

[50] Ferrites are used to prevent electromagnetic interference from entering and damaging sensitive equipment.

[51] Refers to nuclear detonations from multiple strikes against the U.S.

Also, in the post-detonation situation, NAWAS is used by the FOC/FAOC primarily to issue AWN to the SWPs. They pass the messaging to localities or the public using available communications according to their state EAS plan and the AWN distribution channels operational in local EOCs.

7.9. Planning for Use of A&W Pathways

Planners should conduct analyses of their area to identify pre- and post-detonation WEA survivability, other impacts of attrition on WEA, and to pinpoint EOCs in the affected urban area that need to be IPAWS COGs.

As noted in earlier chapters, the maximum extent of the HZ is the area that could have a dose rate from radioactive fallout greater than 0.10 R/h and less than 10 R/h. Although this region is outside the DRZ (the area in which acute radiation effects such as radiation sickness can be expected), it is still an area in which controls to mitigate exposures should be considered. It is also important to note that the magnitude of the HZ will initially increase due to fallout deposition and will rapidly (hours to a few days) decrease due to radioactive decay.

Examples of communications infrastructure that may or may not be impacted include AM and FM transmission towers; broadband transmitters (radio and educational broadband service); cell towers; internet service providers; television analog station transmitters; and television digital station transmitters. Cell service areas should also be leveraged with a notion that it is better to send alerts and warnings into an area rather than failing to attempt communications. This information is important when issuing AWN as the IPAWS architecture shows multiple pathways for sending and receiving an alert. However, it is still important to note that A&W capability can be significantly impacted by damage to the communications infrastructure.

The key to providing timely, comprehensive AWN and precise protective actions to those inside and outside the HZ (the area in which public protective actions should be considered) is based on plume predictions. It is an area in which controls to mitigate exposures should be considered. It is also important to note that the magnitude of the HZ will initially increase due to fallout deposition and will rapidly (hours to a few days) decrease due to radioactive decay.

After detonation, the public in the HZ should have received warnings; however, those in this zone should continue to receive A&Ws to take protective measures. For areas where there is significant exposure, possible damage, and complete destruction of cell towers, loss of electrical power and internet accessibility, it is critical to use alternative networks and transports (i.e., satellite or other means) to get the AWN information out. Planners and responders should look outside the HZ for other EOCs, as well as state, regional or national assets who can perform the A&W function based on prior MOAs or multi-jurisdictional agreements. It is also possible that since the incident is localized, a significant part of the country, including the IPAWS-OPEN primary and cloud-based servers, can still be useful based on access to internet and other critical pathways. Broadcasts from AM and FM radio stations should continue to be emphasized.

In addition, emergency planners should ensure all multi-jurisdictional, local, state, and regional MOAs and MOUs are in place.

Issues involving cybersecurity, hacking, and concerns identified in the *DHS Strategy for Protecting and Preparing the Homeland Against Threats of Electromagnetic Pulse (EMP) and Geomagnetic Disturbances*

(GMD) highlight threats against infrastructure. These concerns are further highlighted in a title in the 2020 National Defense Authorization Act (NDAA) as it relates to AWN. This legislation means that planners must continue to incorporate multiple paths to send and receive AWN and other emergency messaging.

In planning for AWN, the pre-detonation goal is to issue a warning within tens of minutes before the event—a Presidential message from both NAWAS and the NPWS. It would be followed by local alerting to get out numerous 90- and 360-character WEAs and EAS alerts as soon as possible using pre-scripted messages. It is critical that alerting authorities have been trained, are proficient and have validated that their certificates are always up to date with the IPAWS PMO. The exact message texts for these WEA and EAS alerts are the topic of several FEMA workshops held with technical experts. The goal is to publish this information in the future as well as coordinate with the authors on a new version of C*ommunicating in the Immediate Aftermath*.

Since the mandated shelter alert "Get Inside, Stay Inside, Stay Tuned" needs to go out immediately, it is literally based on where the upper winds are blowing and EVERYONE downwind (how far depends on the yield and height) should receive the shelter notice. It is important to note that the IMAAC product displays all the characteristics of the HZ as it moves over time. New tools under development by DHS may be able to provide additional information based on forecasted winds at various altitudes.

For post-detonation estimates, the IMAAC[52] will distribute an initial product to all EOCs, JICs, and JOCs within 15 to 30 minutes. IMAAC's initial product will kick-start the post-detonation operational planning. Once communication can be established with the IMAAC, more detailed estimates will be available through an initial product to all EOCs, JICs, and JOCs to support operational planning and more detailed protective action messages.

Action Item

Examine assets outside of expected HZs to assess backup resources and redundancies.

If the incident is localized, a significant part of the country (including IPAWS-OPEN servers) may remain physically unaffected, based on access to internet and other critical pathways. Broadcast from AM and FM radio are very important sources of AWN.

In summary, planners must operationalize A&W with full knowledge of their alerting capability and the status of all critical infrastructure that could be impacted by a nuclear detonation.

[52] IMAAC is a hazard modeling projection tool for CBRN events. IMAAC is comprised of seven core members—FEMA, DoD, DOE, EPA, HHS, NOAA, and NRC.

Action Item

Ensure AWN is operationalized using regular AOT tools and emerging technologies.

Appendix 1.1: Electromagnetic Pulse (EMP), High-Altitude EMP (HEMP), and Geometric Disturbance (GMD)

The topic of Nuclear EMP has received significant coverage in available publications, with several of the important aspects not well identified. This brief synopsis of key terms provided in this appendix is intended to clarify the topic that is covered in this planning document, as well as provide context for questions that are likely to arise during the planning process. As the focus of this guidance document is on low-altitude nuclear detonations, detonations occurring at other altitudes are only discussed briefly in this appendix.

Low-Altitude SREMP

A Source-Region Electromagnetic Pulse (SREMP) is generated in the region near low-altitude nuclear detonations less than 5 km (~3 miles) above ground level and is the focus of this guidance document. SREMP is caused by the radiation interacting with the air molecules, creating a charge separation with the associated electric fields. The SREMP electric fields can be very high but fall off rapidly with distance from the detonation. SREMP is characterized as a very short duration (typically less than a millisecond), high-amplitude electric field.

There are two major disruptive effects from the SREMP that must be taken into consideration:

1. Radiative effects in which the electromagnetic fields produced by the detonation travel through the air and can affect electronic equipment through induced voltage and current on its internal wires and conductors. The radiative threat for SREMP is limited by the strength of the electric field generated and the distance to which this field can damage or upset electrical equipment. Different types of equipment have different thresholds for damage or upset. SREMP damaging radiative effects extend roughly as far from the detonation as the SDZ.
2. Coupled line charges create large voltage and current surges in long running power lines and other conductors that pass near the detonation point. SREMP coupled to long conductors, such as power lines, can travel significant distances, depending on the topology of conductors, so the discussion here is generalized. For example, a power system with few branching connections can conduct an electrical pulse for several tens of miles, while a power system with more branching can only carry a pulse a few miles. Figure 44 demonstrates a notional example of this effect. Coupling with transmission lines and into substations can potentially damage transformers or burn out relays up to 12 miles away. For example, in an analysis of three different U.S. cities, the range that some substations may be damaged was about 2 miles to 22 miles, depending on the grid design (Pennington et al., 2020). Similarly, substation circuit breaker trips could potentially occur from about 3 miles to 60 miles.

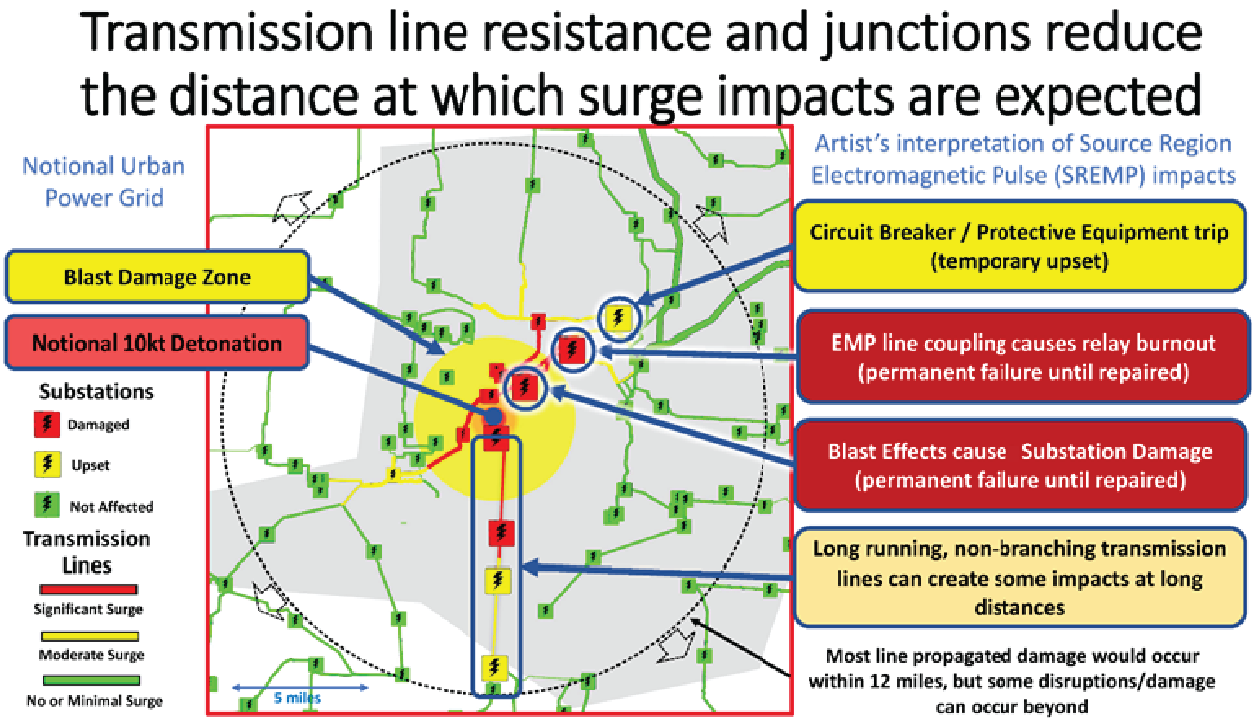


Figure 44: Notional SREMP Impacts on an Electrical Grid

Equipment attached to commercial power can experience damage 5–10 miles from the detonation, depending on electric power system characteristics. Backup power and surge protection can mitigate this impact.

Power outages are likely in low-altitude nuclear detonation scenarios. Outages are influenced by a number of factors, including the extent of physical damage caused by the detonation and the power system design. In general, the outages evolve as follows. The detonation causes blast damage and SREMP effects. The electrical system experiences an imbalance of too much load, too much generation, or a combination of both. The system will begin to compensate for this situation but is unlikely to balance immediately. Subsequently, the system will likely shed more load through deliberate and selective blackouts and may take generation off-line to achieve that balance. This results in a cascading outage that extends well beyond the damage zones. The power system will eventually stabilize, and power will be restored where the system has not been physically damaged. Utilities can restore electric power to undamaged areas in a reasonably short time—typically hours to a few days. Repair and restoration where physical damage occurred will take longer and depend on fallout considerations for workers.

The approximate range of SREMP effects in a 10 kT scenario can be seen in Chapter 1, Figure 17. Electromagnetic illumination (radiative) effects, such as permanent failure and temporary damage, are generally contained within the blast damage zones. Notably, this will only affect some of the equipment in the area.

The distances discussed above are applicable for a wide range of nuclear yields. The physics of a SREMP environment is only weakly dependent on yield, so distances change very little for yields ranging from 10 kT to 1000 kT. This is in striking contrast to the blast damage discussed earlier in this document.

HEMP

High-altitude nuclear detonations (those above 30 km) can produce high-altitude EMP (HEMP). The electric fields generated in HEMP are more complex than those from low-altitude detonation. The first portion of HEMP is generated by the initial gamma radiation interacting with the air molecules. This effect results in a rapidly rising high-magnitude, short-duration electric field (typically only a few microseconds). This first part of HEMP can be a strong electric field (perhaps a few tens of kilovolts per meter) that can exist over a large area (perhaps the size of Nebraska or a bit larger). Unprotected electronic devices may be damaged or electrically disrupted, requiring reset or power cycling, though devices connected to long conductors are at greater risk.

The second component of HEMP is generated by scattered gamma rays and neutrons interacting with the air molecules to create a second pulse, beginning at about a microsecond and extending to many milliseconds. This component is like the electric field created by a nearby lightning strike. Often this component is not included in EMP assessments because lightning protection devices mitigate its effects.

The final portion of HEMP is a much slower rising and lower-level electric field. It is composed of two different effects. The first is the blast effect in which the expanding plasma ball from the detonation disturbs the Earth's magnetic field—much like a magnetic bubble separating the magnetic field lines—thus creating an electric field. The second is the heave effect resulting from two phenomena: (1) X-rays create a heated, conductive patch in the atmosphere, which then deflects the Earth's magnetic field lines creating an electric field and (2) beta radiation works in concert with bomb debris to create an electric dynamo in the upper atmosphere to create an electric field. The heave effect is analogous to that created by solar activity, which can result in significant Geomagnetic Disturbances (GMD). In either case, the slow-rising, long-duration portion of HEMP results in a low-frequency electric field with relatively low magnitude (volts per kilometer). The effects are described below in the next section.

GMD

The interaction of large numbers of charged particles from the sun (like a coronal mass ejection that hits the Earth) interacting with the Earth's magnetic fields can cause a geomagnetic disturbance (GMD). GMDs can create low-frequency electric fields similar to those created by the slow-rising, long-duration portion of HEMP. These low-frequency electric fields can couple to long conductors, like power transmission lines, resulting in low-frequency electric currents. GMD incidents can last several minutes, hours, or days and can cover large areas. The primary GMD threat is to large power transformers overheating, so both the magnitude (volts/km) and duration of GMD effects are critical issues.

Appendix 1.2: Residual Radiation Variability

The fallout plume from a nuclear detonation can behave unpredictably and is strongly affected by the environment. This appendix describes some reasons why residual radiation levels may vary from model predictions or initial estimates.

Residual radiation fields (HZs and DRZs) differ greatly based on contextual variables

HZ and DRZ behavior vary depending on:

- Nuclear yield and HOB
- Environmental characteristics, such as those listed below, impact the amount of debris, fallout particle size, cloud lofting, and fallout particle settling that in turn affects the downwind patterns of residual fallout radiation:
    - Urban, suburban, soil, desert conditions
    - Underground cavities like parking structures, building basements, tunnels, exposed rock formations
    - Coastal/shoreline, river, harbor, open ocean settings (for example, near-surface detonations over water may produce lower residual radiation exposure rates compared the same nuclear yield and HOB over land)
    - Grassland/forest settings
- Meteorological conditions can greatly affect the cloud rise, fallout, and residual radiation, including the following:
    - Surface-level and upper-level wind speed and direction affect the direction and downwind extent of fallout patterns at local, regional, and continental-scale distance.
    - Precipitation can cause rainout and washout of airborne particles and produce areas of significant ground contamination. HZs/DRZs may require emergency operations in areas that did not suffer blast damage, initial radiation, or local fallout. Hot spots of ground contamination caused by washout and rainout of airborne particles may generate additional HZs and DRZs that are geographically separated from the local fallout HZs and DRZs.
    - Winds, temperature, and humidity as a function of altitude will affect how high the cloud will rise, which then affects the direction and extent of residual radiation fallout fields.
    - Changing wind conditions may resuspend fallout particles back into the air, resulting in changing DRZ and HZ boundaries over time. (This effect is unpredictable and difficult to model.)

Meteorological conditions may cause significant variations in fallout patterns

Fallout patterns will vary greatly due to meteorological conditions. For example, wind shear[53] can result in irregularly shaped ground contamination areas, and corresponding DRZs and HZs; additionally, land-sea breezes can generate wind directions at higher altitudes 180 degrees opposite those observed on the ground. Such wind-shear influence was observed in U.S. historical nuclear testing, even when shot times were selected for simpler weather conditions. Figure 45 depicts the complex wind-induced fallout pattern from Teapot Turk, a 43 kT nuclear test detonated at 500 ft above the surface of the Nevada Test Site (NTS). The three wind vectors in Figure 45 show dramatically different wind directions at different altitudes, which produced three different lobes in the fallout pattern on the ground.

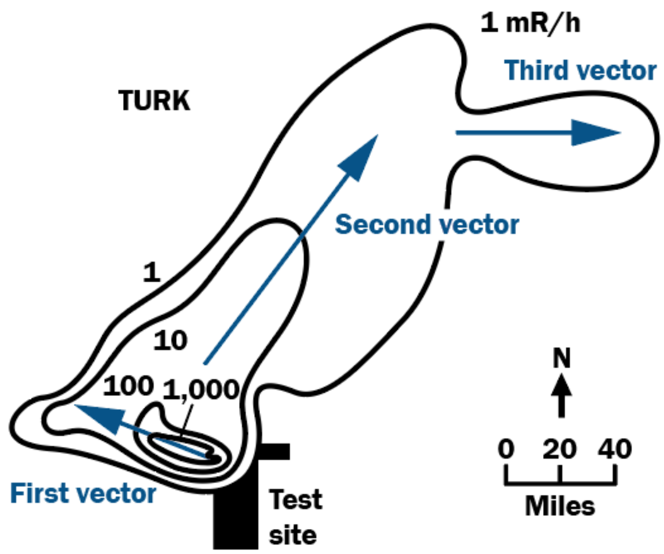


Figure 45: Early Fallout Dose-Rate Contours from the TURK Test at the NTS (derived from Glasstone & Dolan, 1977)

Rainout of airborne radioactive particles may generate additional HZs and DRZs that are geographically separate from the local fallout. These separate HZs and DRZs could still be within the local emergency response area, while outside the physical damage zones. They may affect populations much farther downwind, in neighboring jurisdictions.

Fallout clouds and patterns from a nuclear detonation in an urban environment may vary significantly from nuclear tests

Nuclear fallout clouds from detonation in or near urban structures or underground, such as in a subway tunnel or parking structure, may be quite different than above-ground tests. Urban and underground detonation may not produce the classic mushroom cloud shape due to a number of factors, including:

53 Wind direction and speed change with altitude.

- Urban and underground material incorporation into the fireball
- Surrounding buildings partially blocking fallout cloud airflow
- Blast waves reflecting off nearby buildings
- Fireball interacting with building surfaces

For example, a non-mushroom shaped cloud can be seen in Figure 46, depicting a nuclear test performed at the Nevada Test Site in 1955, called Teapot ESS. This 1 kT device was detonated 67 feet underground. The irregularly shaped fallout cloud climbed more than 2 miles in about 5 minutes and maintained a wide, irregular pattern as it traveled downwind. In the Teapot ESS case, fallout contamination on the ground after the test produced dose rates of more than 10 R/hr approximately 3.5 miles away, 1 hour after the detonation.

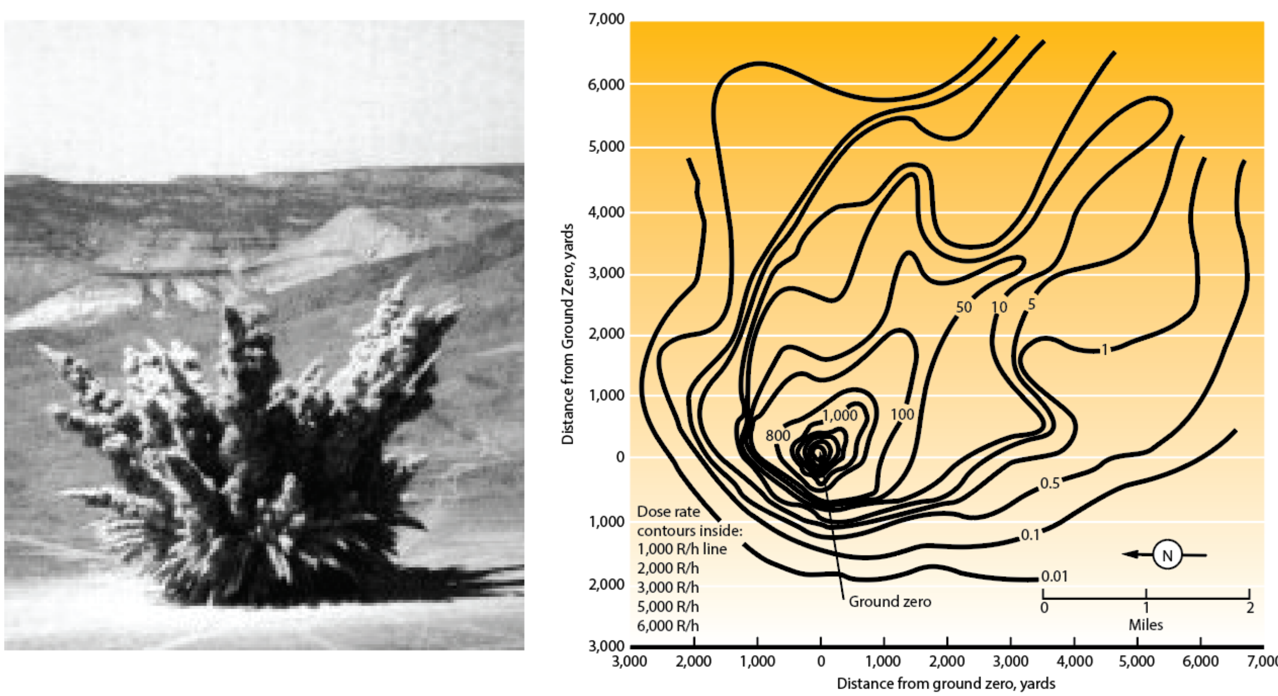


Figure 46: (Left panel) The 1 kT Teapot ESS test, conducted on March 23, 1955. (Right panel) Map of fallout dose rates recorded 1 hour after Teapot ESS. Fallout patterns like this one, which can vary by tens of roentgens per hour over short distances, can make it difficult to establish clear boundaries of the DRZ or HZ, especially in cities with a regular grid of streets. By contrast to this irregularity, simple planning models may output only cigar-shaped clouds. Awareness of this potential irregularity is critical to ensuring plans are flexible enough to account for unusual plume shapes.

Appendix 2.1: Alternative Techniques to Determine Dose[54]

For most emergency workers, the only operational dose and dose-tracking information used may be based on their time at specific locations, matched to an estimate of radiation levels at those locations during those times.

Planners should establish a method for emergency response officials to account for all emergency worker radiation doses. Initial steps to address this are:

1. Creating a communication framework for emergency workers that will enable disseminationof dose-related information.
2. Informing all emergency workers of the critical need to manage dose.
3. Evaluating dose estimation and measurement resources available in advance of an incident and providingrelevant training/guidance.
4. Obtaining or developing additional or improved dosimetry methods as needed. Dosimeters should be distributed to emergency workers when available.
5. Specifying how radiation dose measurements/estimates will be documented, so workers can protect themselves and emergency response officials can make well-informed decisions.
6. Establishing recordkeeping practices to account for every worker's dose as it accumulates. This will enable emergency workers to minimize dose and ensure relevant countermeasures are provided if thresholds are exceeded.

Due to the lack of time to obtain and issue dosimetry equipment, extreme infrastructure damage, and the scale of dosimetry needs, it is not practical to ensure every emergency worker is issued a dosimeter before exposure to radiation. Regardless, plans must include guidelines for addressing dosimetry needs. For example, emergency workers may repurpose equipment that was not specifically designed to estimate and control dose, such as personal radiation detectors (PRDs). If there are not enough dosimeters, group dosimetry may be necessary, where individual doses may be assigned using one person's dose assessment as a surrogate for others in the same group or vicinity.

Dosimetry in the Early Phase of the Response

Although radiation levels can change rapidly with location, monitoring occupancy time is an essential exposure control tool when radiation levels are relatively uniform over time and location. The standard ICS accountability system can be used to track individual/group dose. However, during complex incidents, it is necessary to establish a separate dose tracking or data management unit within the ICS structure. Dosimetry plans must include information gathering from the beginning of the incident for future dose reconstruction. If

[54] This entire appendix is derived from NCRP Report No. 179, *Guidance for Emergency Response Dosimetry*, and reprinted with permission of the National Council on Radiation Protection and Measurements, ncrponline.org/publications.

early data are recorded, this will facilitate dose reconstruction to determine emergency workers' doses. If early ICS record-keeping is not comprehensive, this will introduce uncertainties.

In the early response phase (first hours and days), important ICS dosimetry roles and responsibilities include:

1. Allocate and prioritize limited monitoring equipment based on expected radiation levels, mission time, and equipment capabilities.
2. Maximize dose monitoring coverage, despite limited equipment, by issuing one piece of equipment for each group of responders that deploys, works, and returns together. Group dosimetry is similar to issuing radios and communication devices to responder's groups. Not everyone gets a radio, but it is assumed that all responders will be near their team member/partner with a radio. Radios are issued to ensure maximum coverage and safety—monitoring equipment can be viewed the same way.
3. Establish and implement dose-tracking procedures.
4. Maintain detailed location records of where responders work on the incident and for how long to facilitate later dose reconstruction.
5. Provide responders with monitoring equipment and relevant training to the greatest extent possible. During the early response phase, it is acceptable to conduct operations with limited dose measurement capabilities, provided ALARA is practiced, and available monitoring and dose-tracking resources are optimized.
6. Utilize radiological/nuclear detection equipment to support dose control and monitoring, provided the equipment can perform that role. Tables 9 and 10 summarize equipment types and their operation and capabilities.
7. Ensure dose reconstruction data are available by tracking responder locations and times, even when radiation levels are unknown.

Refer To

Biologically based assays are utilized to assess an individual's dose. They may be referred to as biodosimetry or biodose. This is further detailed in Chapter 4: Acute Medical Care.

Table 9: Equipment for Emergency Worker Dose Monitoring

Equipment	Description	Responder Dose Monitoringand Control Applicability	Features and Components
Handheld survey meters	A very broad category of equipment. Typically used to monitor contamination or radiation in the workplace. Operational range and readout units depend on specific configurations.	**Advantages:** This broad category of survey meters have been used inradiological and nuclear facilities for decades and therefore have a broad occupational worker user base that understands their use. **Limitations:** The occasional user, such as an emergency worker, mayfind using these devices confusing because many display several orders of magnitude on the scale. Correct interpretation requires an understanding of which probe is attached and how to change (and multiply) the scale of the reading.	Geiger-Mueller (GM) detectors, ion chambers, and scintillator-based handheld meters.
Personal dosimeter	A small radiation monitor worn by an individual. These robust, passive devices only provide an assessment of accumulated personal dose after being processed by a laboratory.	**Advantages**: Records personal dose equivalent with accuracy similar to that needed for power plants or similar industrial uses. Some dosimeters can be read with portable equipment, enabling immediate field readings. **Limitations**: Only records accumulated exposures and does not help the responders avoid exposure (i.e., lacks real-time displays and alarms).	Common individual dosimeters contain film, thermoluminescent dosimeter (TLD), optically stimulated luminescent (OSL) materials, or direct-ion storage (DIS)

Equipment	Description	Responder Dose Monitoringand Control Applicability	Features and Components
Pocket ionization chamber	Small devices worn by an individual. Typically, the size of a large pen and comes in a variety of exposure ranges. Also known as quartz-fiber dosimeters, self-indicating pocket dosimeters, or self-reading pocket dosimeters.	**Advantages**: Minimal maintenance and can operate without batteries. Can be read in the field to provide real-time accumulated exposure information to the user. **Limitations**: Must be charged before use, and all readings must be recorded at the end of the mission, as the device does not retain a record. These do not warn workers of hazardous conditions. Difficult to read in the field, especially when wearing a respirator or self-contained breathing apparatus. May provide false readings if subjected to mechanical shock. Comes in a variety of dose ranges, requiring careful selection.	Looking through the device, users can see a needle indicating exposure level.
Electronic personal dosimeter (EPD)	Worn by an individual to measure personal dose equivalent. Displays dose and dose rate, and many will alarm when preset thresholds are exceeded.	**Advantages**: Provides immediate information and alarm functions to control exposure. Since these can display exposure rate, they also can be used as high-range survey instruments. **Limitations**: Many of these are too fragile for the rigors of emergency response; these devices lack large displays, vibration, or loud audible alarms. Difficult to change alarm set points in the field or reset dose accumulation between missions. The American National Standards Institute (ANSI) standard requires measurements up to 100 R/hr and 100 R, although many devices exceed this.	Typically use semiconductor detectors such as a metal-oxide semi-conductor field-effect transistor.
Personal Emergency Radiation Detectors (PERDs) and Monitors	Worn by an individual to measure personal exposure. PERDs display dose and dose rate and will alarm if preset thresholds are exceeded.	**Advantages**: PERD ranges are appropriate in the elevated radiation area, HZ, and DRZ, making them the preferred tool to ensure responder safety. PERD accuracy is the same as EPDs, but the higher range (0.001 to 999 R/hr) ensures the instrument will not oversaturate. Built to endure the hardships of emergency response. Vibration and loud audible alarms. Field-adjustable parameters. **Limitations**: The ANSI standard for PERDs requires an effective dose-rate range down to 1 mR/hr; this may limit their use in the elevated radiation area, although many devices have a larger effective range.	These instruments typically use a small Geiger-Mueller tube or solid-state detector.

Equipment	Description	Responder Dose Monitoringand Control Applicability	Features and Components
Personal radiation detectors (PRDs)	Similar in appearance to electronic dosimeters; PRDs detect low levels of radiation for law-enforcement activities. Developed to help find and intercept potential radiological/ nuclear threats.	**Advantages**: Alerts wearers to any low levels of radiation. Useful for emergency response activities outside of the HZ. **Limitations**: The ANSI standard (ANSI 2011) does not require tracking integrated or cumulative exposure, although some manufacturers add this capability. The standard requires an exposure rate range up to 2 mR/hr. Due to their sensitivity, these devices often saturate at relatively low radiation levels and cannot be used in the HZ or DRZ.	Typically use very sensitive crystal or plastic scintillators.
Extended range PRDs	PRD manufacturers have begunoffering dual detector systems that allow the PRD to have an extended (high) dose-rate rangewithout sacrificing the lower dose-rate sensitivity.	**Advantages**: If designed to track exposure rate and total exposure, it would be an appropriate tool for responder protection and monitoring in the HZ and DRZ (if the device can support exposure rates up to 500 R/hr). A reasonable tool for both public safety and security applications. **Limitations**: Alarm set points must be changed to match mission needs—preset thresholds would negatively impact emergency response operations.	In addition to sensitive crystal or plastic scintillators, manufacturers often add a second, less sensitivedetector such as a small Geiger-Mueller or solid-state detector.

Additional specialized instrumentation, such as radioisotope identification devices, backpack and vehicle-mounted systems may also be able to support responder dose control. See Table 10 for how various equipment can support response missions.

Table 10: Mission-Oriented Detector Selection (adapted from NCRP 2017, Table 4.4 and FEMA 2010 Table)

Mission	Personal Dosimeter	Pocket Ionization Chamber	Alarming Electronic Personal Detector (EPD)	Personal Radiation Detector (PRD)	Extended Range PRD	Personal Emergency Radiation Detector (PERD)	Low-Range Survey Meter	High-Range Survey Meter	Radio-isotope Identification Device	Large Mobile and Trans-portable	Aerial	Portal Monitor	Backpack	Sensor Networks	Medical Instrumen-tation
Cold zone [less than ~0.1 mGy h^{-1} (10 mR h^{-1})]															
Emergency worker exposure control	⦸ ○[D]	○	●	●	●	●	○	○	○	○	⦸	⦸	⦸	●[A]	⦸
Emergency worker dose monitoring	●	○	●	⦸ ●[A]	⦸ ●[A]	●	⦸ ○[A]	⦸ ○[A]	⦸ ○[A]	⦸	⦸	⦸	⦸	●[A]	⦸
Contamination screening (β/γ)	⦸	⦸	○	●	●	⦸ ●[B]	●	○	●	●	⦸	●	○	⦸	⦸
Radiation survey (cold zone only)	⦸	⦸	⦸	○ ●[C]	●	○ ●[B]	●	○	●	●	●	⦸	○	●[A]	⦸
Radiation Monitoring at Shelters	⦸	⦸	○	●	●	●	●	⦸	⦸	⦸	⦸	⦸	⦸	⦸	⦸
Establish Evacuation Routes	⦸	⦸	●	●	●	○	○	●	○	○	●	⦸	○	○	⦸
Population Monitoring at Medical Faciiities	⦸	⦸	○	○	●	●	○	⦸	○	⦸	⦸	⦸	⦸	⦸	○
Hot zone [>0.1 mGy h^{-1} (10 mR h^{-1})]															
Emergency worker exposure control	⦸ ○[D]	○	○ ●[G]	⦸	○ ●[H]	●	⦸	○	⦸	⦸	⦸	⦸	⦸	●[E]	⦸
Emergency worker dose monitoring	●	○	○ ●[G]	⦸	⦸ ●[A, E]	●	⦸	⦸ ○[A]	⦸	⦸	⦸	⦸	⦸	●[E]	⦸

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Mission	Personal Dosimeter	Pocket Ionization Chamber	Alarming Electronic Personal Detector (EPD)	Personal Radiation Detector (PRD)	Extended Range PRD	Personal Emergency Radiation Detector (PERD)	Low-Range Survey Meter	High-Range Survey Meter	Radio-isotope Identification Device	Large Mobile and Trans-portable	Aerial	Portal Monitor	Backpack	Sensor Networks	Medical Instrumen-tation
Radiation survey (hot zone only)	⦸	⦸	○	⦸	○	●	⦸	●	⦸	⦸ ●[E]	●	⦸	⦸	●[E]	⦸
Dangerous-radiation zone [>0.1 Gy h^{-1} (10 R h^{-1})]															
Emergency worker exposure control	⦸	○	○ ●[F, G]	⦸	○ ●[F, G]	○ ●[F, G]	⦸	○	⦸	⦸	⦸	⦸	⦸	●[F]	⦸
Emergency worker dose monitoring	●	○	○ ●[F, G]	⦸	○ ●[A, G]	○ ●[A, G]	⦸	⦸ ○[A]	⦸	⦸	⦸	⦸	⦸	●[F]	⦸

[a]Symbol key:

- ● = Useful; Appropriate for the mission
- ○ = Marginal; meets minimum requirement
- ⦸ = Not useful; insufficient for the mission
- A = Provided instruments have the capability to track accumulated exposure or dose
- B = Provided instruments have the capability for low-range [down to ~1 μGy h^{-1} (0.1 mR h^{-1})] exposure monitoring
- C = Provided instruments can readout in exposure or dose rate and do not automatically adjust for background
- D = Provided the dosimeter has the capability for readout in the field
- E = Provided instruments have the capability for high-range [up to ~0.1 Gy h^{-1} (10 R h^{-1})] functionality
- F = Provided instruments have the capability for very high-range [up to ~10 Gy h^{-1} (1,000 R h^{-1})] functionality
- G = Provided instruments have the loud audible and vibration alarm

Useful – This is a device that can effectively perform the designated mission or task without modification of the device or of its normal mode of employment. In a sense, the device was designed or intended for that mission or task.

Marginal – The device can provide useful and relevant data in support of the designated mission or task but with modification to the normal mode of employment. In addition, its use may create a potentially unsafe condition to the user of the device. This implies a need for care in the interpretation of the data produced by such a device under the circumstances.

Not Useful – While the device is capable of detecting nuclear radiation, its technical performance characteristics or conditions of use are such that it is unlikely to be able to provide useful information in support of the designated mission or task. In addition, its use may create a grossly unsafe condition to the user of the device.

Appendix 2.2: Decontamination of Critical Infrastructure

Several factors should be considered when assessing critical infrastructure decontamination needs:

1. The DRZ may involve lethal, non-uniform fallout deposition, or hot spots. Responders working in areas with significant fallout contamination require real-time radiation measurements, and a robust, actively managed personal dose-monitoring system.
2. Fallout decays rapidly (see Chapter 1), so it is generally preferable to delay infrastructure decontamination activities, if possible. Temporary solutions to reduce exposure to workers at critical infrastructure facilities include:
    a. Burying radioactive contamination by tilling contaminated soil in the surrounding area. Leaving the tilled soil rough reduces radiation exposure.
    b. Adding or enhancing shielding (heavy materials) around key locations of interest. Consider use of concrete highway barriers and/or earthen and rubble berms.
    c. Washing/spraying down vegetation (e.g., trees) and other elevated surfaces.
3. Where possible, infrastructure outside the HZ and DRZ should be used. These facilities and locations could be available immediately and can be expected to be free of contamination. FEMA's Continuity of Operations Program (COOP) guidance and planning resources can be used as a template for local emergency preparedness planners and can help them choose appropriate COOP locations that will not be affected by fallout or require decontamination.
4. If decontamination is required in the early hours after a nuclear explosion, local responders may perform these duties, despite little or no radiological decontamination training.
5. Consider effective, fast, and easy-to-implement decontamination methods, such as vacuuming, showering, and hosing.
6. Decontamination targets are key for identifying when infrastructure is "clean." While background radiation times two is widely used as a general estimate, the EPA will ultimately set decontamination target guidelines for access.

Refer To

FEMA COOP brochure: www.fema.gov/pdf/about/org/ncp/coop_brochure.pdf

Critical infrastructure decontamination should only be initiated when basic information becomes available regarding fallout distribution, current and projected radiation dose rates, and structural integrity of the elements to be decontaminated. There are several references and tools for critical infrastructure decontamination planning and assessing dose to workers—see Refer To below.

Refer To

For more information on decontamination method selection, see:

- NCRP Report 175, *Decision Making for Late-Phase Recovery from Major Nuclear or Radiological Incidents:* ncrponline.org/publications/reports/ncrp-report-175
- The residual radioactivity (RESRAD) family of codes available for free download: www.evs.anl.gov/research-areas/highlights/resrad.cfm
- A *Radiation Decontamination Planning Tool* is available on RadResponder's resource page, though an account is required for access.

It is important to estimate how much decontamination is required to use or occupy each area, and how long each area must be used. Emergency response and SLTT officials must determine which infrastructure requires decontamination and what level of decontamination is necessary. Planners must consider the level of effort, responder exposure, PPE availability, and waste management. Natural decay of radioactive contaminants must be accounted for in dose estimates.

Early infrastructure decontamination is intended to remove a substantial portion of contaminant to lower radioactivity and facilitate use or occupancy. Effective decontamination methods utilize equipment and operator skills that are immediately available, such as:

1. Vacuuming/vacuum sweeping
2. Fire hosing/rinsing
3. Washing with detergents or surfactants
4. Steam cleaning
5. Surface removal using abrasive media (e.g., sandblasting)
6. Vegetation and soil removal
7. Road resurfacing

In general, more effective methods take longer and require more skilled operators. The above methods have been demonstrated to remove 2,095% of existing contamination in various conditions, but many factors must be considered to select the most effective method.

Refer To

For more information on method selection, see NCRP Report 175, *Decision Making for Late-Phase Recovery from Major Nuclear or Radiological Incidents*.

Appendix 2.3: Waste Management Operations

A nuclear explosion will generate large quantities of waste and debris. Moreover, decontamination and cleanup activities will also generate waste. All wastes will require proper characterization, segregation, transportation,and disposal. Waste streams will be highly variable, ranging from building debris and contents (concrete rubble, soil, structural metal, asbestos-containing materials, carpets, wallboard, electronics, etc.) to contaminated fluids, sludge, animal carcasses, vegetative debris, and human remains.

Decontamination decisions can profoundly impact waste disposal options and waste quantities. Additionally, waste disposal costs and legal or practical barriers may impact the decontamination strategies. SLTT waste management personnel should be included in the planning process to advise responders, develop an understanding of likely debris, and identify appropriate equipment to remove obstacles and obstructions. State and local waste management personnel should pre-select potential site(s) for short-term waste storage. Waste management plans should include messaging to address the public affected by waste storage or transportation. Some debris and waste piles may contain human remains, which will require special handling procedures.

Traditionally, waste management operations begin after lifesaving operations, situation stabilization, and evidence collection. However, during a large-scale incident like a nuclear explosion, waste management operations will overlap with search and rescue, criminal investigations, and human remains recovery.

During initial roadway clearance, the priority will be to push debris to the sides of the road and provide access, rather than removing the debris to staging or holding areas. Given limited resources in the first 72 hours, it is more important to clear access routes for emergency vehicle movement than to begin debris removal operations. Waste management personnel may relocate debris to temporary staging points, where debris can be examined for human remains and segregated, though search and segregation is not a priority in the first 72 hours.

Debris downwind of the blast area will likely be radioactive, while debris far upwind will likely have little contamination. Considering the extent of debris contamination is important when determining the management methods. Plans should include measuring debris radioactivity, addressing removal equipment contamination, and avoiding co-mingling contaminated and uncontaminated debris.

Hot spot removal will reduce emergency responder radiation doses, enabling them to respond for longer time periods. Hot spot removal is another waste management activity that may be necessary during the initial hours. Removing a hot spot may include washing down the area, scraping up contaminated soil, or similar removal activities. Hot spots are areas with high concentrations of radiation, posing a greater threat to response workers and the public.

In summary, in the first 72 hours, planners should consider the following:

- Waste management officials must work with ICs to identify waste management priorities.

- Waste management operations must prioritize worker safety and health. Worker training must be coordinated in advance of an incident.
- Clearing debris from roads and other infrastructure will be a response priority to facilitate lifesaving and other emergency response activities. This action will likely be limited to moving debris to provide safe ingressand egress corridors.
- Promptly removing highly contaminated materials or hot spots may be necessary to reduce exposure.

Locations and mechanisms must be identified for screening debris that may contain human remains. Additionally, locations and mechanisms must be established for staging, holding, short-term storing, categorizing, segregating, transporting, and preparing waste for disposal.

Appendix 4.1: LD50/60

ARS in humans can be described with LD50/60, as shown in the diagram below (Figure 47). The curve below applies to victims who do not receive treatment. With currently available treatments and countermeasures, survival is expected to be considerably higher, and the curve will shift to the right.

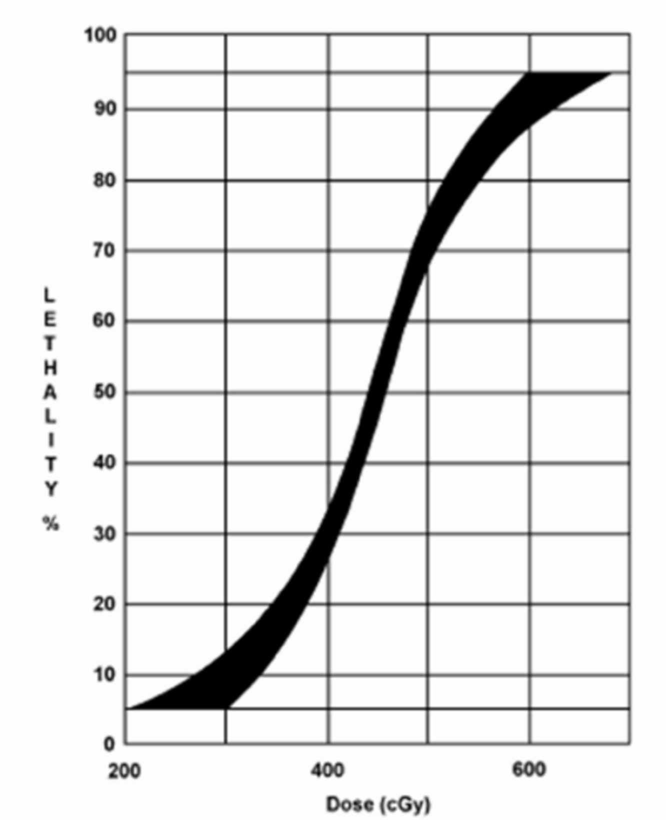


Figure 47: 60-day lethality curve for untreated radiation exposure. The untreated dose that will kill 50% of the population within 60 days (LD50/60) is approximately 450 cGy (450 rad) (derived from *Multiservice Tactics Techniques and Procedures for Treatment of Nuclear and Radiological Casualties,* 2014).

Appendix 4.2: Subsyndromes of ARS

The four ARS subsyndromes described in this document are hematopoietic subsyndrome (H-ARS), gastrointestinal subsyndrome (GI-ARS), cutaneous radiation subsyndrome (C-ARS), and neurovascular subsyndrome (N-ARS). H-ARS is described in Chapter 4, Section 1.3. The other three subsyndromes are described in this appendix.

Gastrointestinal Subsyndrome (GI-ARS)

GI-ARS manifestations typically begin at whole body radiation doses in excess of 6 Gy (600 rad). The severity and time of onset of GI-ARS are affected by many factors including total dose received, dose rate, host factors, etc.

Initially, GI-ARS symptoms include nausea, vomiting, and diarrhea, potentially causing dehydration, electrolyte imbalances, GI bleeding, and systemic infections. GI-ARS symptoms are non-specific and can be caused by other psychological or physical injuries, meaning their presence alone does not automatically signal GI-ARS (Dainiak et al., 2011b; DiCarlo et al., 2011).

GI-ARS treatments include countermeasures for nausea, vomiting, diarrhea, infection, fluid loss, and blood replacement. Cytokines for H-ARS do not affect G-ARS manifestations directly, but H-ARS improvements may affect GI-ARS. If patients require hospitalization for GI-ARS, they will likely be in the hospital for H-ARS already.

Cutaneous Radiation Subsyndrome (C-ARS or CRS)

Cutaneous radiation subsyndrome (C-ARS) occurs when significant levels of ionizing radiation penetrate deeply into tissues. Severity and time of onset depend on dose, dose rate, radiation quality, and the total body area affected. Whole body doses sufficient to cause cutaneous and neurovascular subsyndromes are typically lethal. Additionally, such doses would be sustained by people near the blast who would likely have additional lethal injuries, so treatment efforts would be futile.

C-ARS presents similarly to thermal injuries, and many treatment options apply to both. At high doses, C-ARS presents almost immediately with early skin erythema (reddening of the skin) followed by a latent period (days to weeks). Later symptoms result in blisters, ulcers, itchiness, tingling, epilation (hair loss), erythema, and edema (swelling caused by fluid buildup) (Fliedner et al., 2001; CDC, 2005). One *major difference*, detailed below, is that there may be a much greater depth of injury for radiation burns than thermal burns, requiring deep tissue management.

The clinical severity and time of onset of the signs and symptoms of C-ARS depend on total dose, dose rate, radiation quality, radiation energy (the higher the energy, the deeper the penetration), the precise location of the radiated skin, and the TBSA affected.

Skin affected by radiation injury can become infected and require anti-microbial treatment. Similar to thermal burns, the greater the skin area affected by radiation burns, the greater likelihood of fluid loss, requiring expertly calculated fluid replacement therapy. Skin grafting may be necessary to cover larger and deeper wounds (Dainiak et al., 2011b; Rios et al., 2020).

C-ARS treatment is based on standard non-radiation-induced skin injury treatment, such as anti-inflammatory agents, topical antibiotics, and antihistamines. Surgical excision may be warranted to remove ulcers and necrotictissue. Skin grafts can also be considered.

Neurovascular Subsyndrome (N-ARS)

As mentioned above, whole body doses sufficient to cause cutaneous and neurovascular subsyndromes are typically lethal, and most treatment efforts would be futile. For scarce resource environments—or even fair resource conditions—care for N-ARS is primarily palliative.

N-ARS is caused by high-dose radiation damage to the brain and blood-brain barrier. [55] N-ARS is commonly lethal hours to days post-exposure. Symptoms include headache, nausea, vomiting, confusion, altered mental status, fever, hypotension, seizures, and coma. Treatment is complex supportive care, including fluid management (usually restriction), anti-seizure medications, corticosteroids, anti-nausea medications, pain management, and blood pressure management (Dainiak et al., 2011b).

[55] The blood-brain barrier is a semi-permeable membrane that selectively allows solutes in the blood to cross into the extracellular fluid of the central nervous system, where neurons reside.

Appendix 4.3: Burn Injuries

Whether from thermal or radiation injury, depth of a burn injury, where the burn is located, and %TBSA involved are keys to appropriate therapy. Burn surface area is measured relative to the TBSA, designated as %TBSA. Meanwhile, burn depths are characterized as (D'Arpa & Leung, 2017):

- **Superficial (1st degree):** involving only the epidermis (surface of the skin). Typically heal spontaneously.
- **Partial thickness (2nd degree):** involving some portion of the dermis. Typically heal spontaneously but may evolve into full thickness burns.
- **Full thickness (3rd degree):** involving the entire dermis,[56] sometimes extending beyond skin tissue, down to muscle or bone. Typically require autologous skin grafting to heal well. Deep radiation burns may require deep tissue resection.

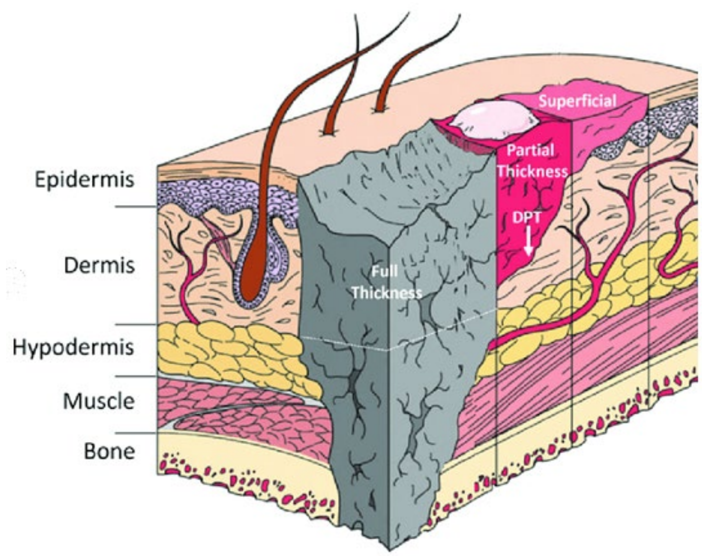


Figure 48: Layers of Skin Tissue with Burn-Depth for Different Burns (derived from D'Arpa et al., 2017)

Refer To

One clinical triage tool on the REMM website includes burn injury input parameters.

[56] The thick layer of living tissue below the epidermis, containing blood capillaries, nerve endings, sweat glands, hair follicles, and other structures

In general, the greater %TBSA covered by partial or full thickness burns and the older the individual, the greater risk of mortality. Casualties with burns >40% TBSA could survive with intense treatment; however, medical resources will be scarce following a nuclear detonation. Casualties with severe burns may not be prioritized because triage systems must allocate resources to save as many lives as possible. After federal resources arrive, patients should be re-triaged based on new resource availability.

For additional burn information, visit REMM's Burn Triage and Treatment of Thermal Injuries in a Radiation Emergency page.

Refer To

REMM's Burn Triage and Treatment of Thermal Injuries and Radiation Burns in a Radiation Emergency:

- remm.hhs.gov/burns.htm
- remm.hhs.gov/cutaneoussyndrome.htm

Appendix 4.4: Triage

In 2011, HHS sponsored the Scarce Resources Project that discussed medical system issues related to a nuclear detonation. The triage recommendations that resulted from this study used the following factors ranked in the following priority, starting from the highest:

1. Mechanical trauma
2. Burn injuries: based on burn depth and %TBSA
3. Radiation dose from whole body exposure
4. Combined injuries: radiation plus trauma and/or thermal burns
5. Comorbid conditions: comorbid conditions that are likely to affect treatment outcomes, such as immunosuppression, dependence on dialysis or lung injuries requiring ventilators

A clinical triage tool using the Scarce Resource Project guidelines is available on REMM and in the Mobile REMM app. Radiation dose, mechanical injury, burn severity, and prevailing resources adequacy are parameters in the tool.

Triage cards, usable by first responders or first receivers, were developed for the Scarce Resources Project (Coleman et al., 2011). The three triage cards below show examples of triage cards that might be used following a nuclear detonation. Input parameters include assigned whole body dose from exposure, injury type(s), and resource adequacy. Output is not only triage category but also priority for receipt of cytokine therapy. Generally, the triage categories and the colored tags assigned to patients associated with these systems are identical or similar to the diagram below.

Black	Expectant	Pain or other comfort medications only, if available, until death
Red	Immediate	Life-threatening injuries, seen and treated first and urgently
Yellow	Delayed	Non-life-threatening injuries, require care but some delay is acceptable
Green	Minimal	Minor injuries which will require care, but delay or hours to days may be acceptable.

Figure 49: Typical Triage Colors, Categories, and Definitions Used During Mass Casualty Triage

Triage card 1: RADIATION ONLY—triage category affected by radiation dose and resource availability

Triage category affected by radiation dose and resource availability
RADIATION ONLY

Radiation Dose* (Gy)	Normal	Good	Fair	Poor
>10* Likely fatal (in higher range)	Expectant[3] / Immediate[2]	Expectant[3]	Expectant[3]	Expectant[3]
6-10* Severe	Immediate[2]	Immediate[2]	Delayed[2]	Expectant[3]
>2-6* Moderate	Immediate[1]	Immediate[1]	Immediate[1]	Immediate[1]
>0.5-<2* Minimal	Minimal B[3]	Minimal B[3]	Minimal B[3]	Minimal B[3]
<0.5* Minimal	Minimal A[3]	Minimal A[3]	Minimal A[3]	Minimal A[3]
Resource availability:	Normal	Good	Fair	Poor
Standard of care**:	Conventional	Contingency	Crisis	Crisis

Legend: Radiation Only

*Radiation dose received by the whole body or a significant portion of the whole body.
**Institute of Medicine. *Guidance for establishing crisis standards of care for use in disaster situations: A letter report.* Washington, DC: Institute of Medicine, National Academies of Science; 2009.

Minimal B: Consider repeating both biodosimetry and clinical reassessments, especially at high end of this dose range
Minimal A: <0.5 Those with physical dose estimates based on location below 0.5 Gy need not report for medical evaluation. Joining a registry may be suggested after the incident.

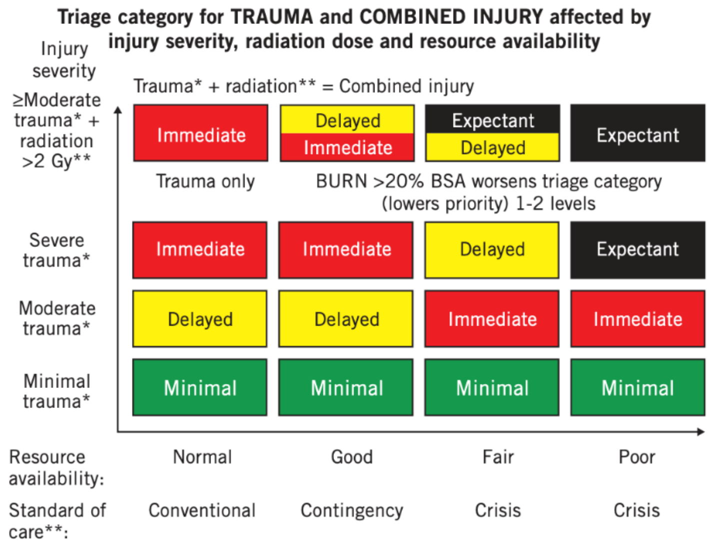
The purple/black split triage category for >10 Gy indicates that some victims may receive aggressive treatment at discretion of physician, especially if 10 Gy is received over prolonged time period.

Resource availability below NORMAL:
GOOD conditions allow for maintenance of "functionally-equivalent" care through contingency operations
FAIR conditions require delaying care for severe injuries after moderate injuries
POOR conditions require classifying severe injuries as expectant

Myeloid cytokine category	G-CSF recommendation
1	G-CSF indicated.
2	G-CSF indicated, lower priority than Category 1.
3	G-CSF not indicated.

Figure 50: Triage Card 1 describes triage for radiation-only patients.

Triage card 2: Triage category for TRAUMA and COMBINED INJURY affected by injury severity, radiation dose, and resource availability



Legend: Trauma and combined injury

*Adding >20% total body surface area burn to trauma worsen triage priority by 1 category (puts them *lower on the priority list*).

Radiation dose received by the whole body or a significant portion of the whole body. **At higher radiation doses (>6 Gy), triage category may worsen–as on Combined Injury card

***Institute of Medicine. *Guidance for establishing crisis standards of care for use in disaster situations: A letter report*. Washington, DC: Institute of Medicine, National Academies of Science; 2009.

Trauma category	Description
Combined injury	• Radiation dose of >2 Gy to whole body or significant portion of whole body *plus moderate or severe* trauma and/or burn injury.
Severe trauma	• Stabilization requires complex treatment; • >20% chance of death even with treatment.
Moderate trauma	• Without stabilization, potential for death within hours • <20% chance of death with stabilization and treatment.
Minimal trauma	• Injuries pose no significant risk to life and limb in next 3-4 days • Limited or no treatment prior to referral in the next 3-4 days.

Figure 51: Triage Card 2 describes triage for trauma and combined-injury patients.

Triage cards 3 and 4: Myeloid cytokine (eg, granulocyte colony-stimulating factor) recommendation for casualties with "minimal trauma/radiation only" and "combined injury"

G-CSF priority categories for "normal or good" resource availability

Radiation Dose* (Gy)	RADIATION ONLY or minimal trauma: Minimal trauma*	COMBINED INJURY Moderate or severe injury* + radiation** > 2 Gy: Moderate trauma*	Severe trauma*
>10 Gy Likely fatal	Expectant[3] / Immediate[2]	Expectant[3]	Expectant[3]
>6-10 Gy Severe	Immediate[2]	Delayed[2]	Expectant[3]
≥2-6 Gy Moderate	Immediate[1]	Immediate[1]	Delayed[2]

G-CSF priority categories for "fair or poor" resource availability

Radiation Dose* (Gy)	RADIATION ONLY or minimal trauma: Minimal trauma*		COMBINED INJURY Moderate or severe injury* + radiation** > 2 Gy: Moderate trauma*	Severe trauma*
>10 Gy Likely fatal	Expectant[3]	Expectant[3]	Expectant[3]	Expectant[3]
>6-10 Gy Severe	Delayed[2]	Expectant[3]	Expectant[3]	Expectant[3]
≥2-6 Gy Moderate	Immediate[1]	Immediate[1]	Delayed[2]	Expectant[3]
Resource Availability:	Fair	Poor	Fair and Poor	

Myeloid cytokine category	G-CSF recommendation
1	G-CSF indicated.
2	G-CSF indicated, lower priority than Category 1.
3	G-CSF not indicated.

Estimating dose from a single Absolute Lymphocyte count (ALC).
SERIAL MEASUREMENTS MORE ACCURATE and are strongly recommended
Using AFRRI BAT tool on REMM is also more accurate.
Instructions: 1) Determine the ALC for that patient, 2) read down by the number of hours after the incident and 3) read across for estimate of whole body dose.
(Table adapted by Scarce Resources Group from AFRRI dose calculator on REMM (www.remm.nlm.gov)

		Absolute Lymphocyte Count (ALC) Value × 10 to the ninth (single value)												
		1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
		Estimate of whole body dose from radiation exposure (Below 2 Gy / 2-6 Gy / Above 6 Gy)												
Hours after exposure	24	0	0	1.8	2.5	3.3	4.2	5.2	6.3	7.7	9.3	>10	>10	>10
	48	0	0	0	1.5	2.0	2.5	3.1	3.8	4.6	5.6	6.9	8.7	>10
	72	0	0	0	0	0.9	1.8	2.2	2.7	3.2	3.9	4.8	6.1	8.2
	96	0	0	0	0	0	0	1.7	2.1	2.5	3.1	3.8	4.8	6.5

Figure 52: Triage cards 3 and 4 describe myeloid cytokine recommendations.

Appendix 4.5: Guidance Resources for Healthcare Providers, Responders, and Planners

Resource	Source	Description	Link
Radiation Emergency Assistance Center/Training Site (REAC/TS)	Oak Ridge Institute	Maintains a collection of radiation emergency medicine resources that support the medical response to radiological/nuclear incidents and the treatment of individuals injured by ionizing radiation. Includes dose estimation procedures, radiation countermeasure information, PPE guidance, and other information specifically for medical professionals.	orise.orau.gov/resources/reacts/index.html
Emergency Radiation Medicine Response Pocket Guide	Armed Forces Radiobiology Research Institute (AFRRI)	Two-page document that includes a flow chart for radiation patient treatment, a table of ARS survivability (including phases), a brief table of symptom clusters, and brief descriptions of case confirmation, treatment considerations, decontamination considerations, reporting, understanding radiation exposure, and diagnosis.	afrri.usuhs.edu/sites/default/files/2020-07/afrri-pocket-guide.pdf
Management of Dead Bodies after Disasters: A Field Manual for First Responders	PAHO, WHO, ICRC, IFR-CRCS[57]	Provides practical, easy-to-follow guidelines for first responder to promote dignified and proper management of dead bodies and facilitate their identification.	www.paho.org/disasters/dmdocuments/DeadBodiesFieldManual-2ndEd.pdf

[57] Pan-American Health Organization (PAHO), World Health Organization (WHO), International Committee of the Red Cross (ICRC), International Federation of Red Cross and Red Crescent Societies (IFRC)

Resource	Source	Description	Link
Medical Management of Radiological Casualties	AFRRI	Succinctly describes emergency biodosimetry, ARS, medical management of skin injury, medical management of internally deposited radionuclides, other injuries from nuclear weapons, psychological support, delayed effect, decontamination techniques, etc.	afrri.usuhs.edu/sites/default/files/2020-07/4edmmrchandbook.pdf
Radiation Emergencies	CDC	A collection of resources tailored to various audiences, including clinicians, public health professionals, laboratorians, etc. Clinician resources focus on patient management, PPE, triage, decontamination, ARS, internal contamination, CRS, and countermeasure guidance.	www.cdc.gov/nceh/radiation/emergencies/index.htm?CDC_AA_refVal=https%3A%2F%2Femergency.cdc.g
REMM	HHS	An extensive tool for medical management during radiological incidents, REMM describes patient management, initial incident activities, management modifiers (based on injuries and medical needs), practical guidance (including use of blood products, decontamination procedures,and population monitoring), etc. Includes resources tailored to specific audiences, such as first responders, mental health professionals, hospital staff, etc. Additionally, most REMM information can be downloaded for use offline, during trainings and response.	remm.hhs.gov/index.html
Radiation Sickness	Mayo Clinic	Briefly and succinctly describes symptoms, diagnosis, and treatment of radiation sickness.	www.mayoclinic.org/diseases-conditions/radiation-sickness/diagnosis-treatment/drc-20377061

Appendix 4.6: Response Support Teams and Planning Resources

Resource	Source	Description	Link
Disaster Medical Assistance Team (DMAT)	HHS	DMATs are staffed with medical professionals who provide expert patient care. DMAT members include advanced clinicians (nurse practitioners/physician assistants), medical officers, registered nurses, respiratory therapists, paramedics, pharmacists, safety specialists, logistical specialists, information technologists, and communication and administrative specialists.	www.phe.gov/Preparedness/responders/ndms/ndms-teams/Pages/dmat.aspx
Disaster Mortuary Operational Response Teams (DMORT)	HHS	DMORTs provide technical assistance and consultation on fatality management and mortuary affairs. DMORTs can: ▪ track and document human remains and personal effects ▪ establish temporary morgue facilities ▪ assist with determination of cause and manner of death ▪ collect ante-mortem data ▪ collect victim medical records, dental records, or DNA from next of kin for victim identification ▪ perform postmortem data collection ▪ document field retrieval and morgue operations ▪ perform forensic dental pathology and anthropology operations ▪ process and re-inter disinterred remains	www.phe.gov/Preparedness/responders/ndms/ndms-teams/Pages/dmort.aspx
Radiation Emergency Assistance Center/Training Site (REAC/TS)	DOE	Provides emergency response and subject matter expertise on the medical management of radiation incidents. REAC/TS provides continuing medical education and outreach exercises.Additionally, the REAC/TS website describes clinical information and training opportunities.	orise.orau.gov/reacts

Resource	Source	Description	Link
Radiation Injury Treatment Network (RITN)	Private Sector	Network of hospitals and medical providers with specific capabilities intreating radiation injuries. The RITN also provides training resources, adult and pediatric medical treatment recommendations, and medical referral assessment for ARS patients.	www.RITN.net
Victim Information Center (VIC) Teams	HHS	VIC teams provide technical assistance for collection and management of ante-mortem data and related issues. VIC teams can: ▪ collect dental records, medical records, DNA, and other ante-mortem data ▪ provide subject matter expertise regarding mass fatality management and victim information procurement ▪ train partners to gather victim identification information from family interviews ▪ coordinate with FSLTT law enforcement ▪ gather ante-mortem data to facilitate victim identification ▪ manage the missing persons list ▪ update the Victim Identification Program (VIP) database ▪ coordinate the release of remains	www.phe.gov/Preparedness/responders/ndms/ndms-teams/Pages/vic.aspx

The tools and resources listed in this section are not all of the resources available for planners on these topics. Readers who want to learn more are encouraged to read the cited sources as well.

Appendix 4.7: Resources for Medical Examiners and Coroners (ME/Cs) and Fatality Management Planning

Resource	Source	Description	Link
Guidelines for Handling Decedents Contaminated with Radioactive Materials	CDC	Procedures and guidance focused on handling radioactive remains. Includes scenario-specific guidelines, addressing nuclear detonation scenarios, radiological dispersal devices (RDD) scenario, and radioactive sources in public places. Discusses relevant instruments, protective precautions for medical examiners/coroners on-scene, morgue procedures, autopsy and funeral home guidance, transportation guidance, etc.	www.cdc.gov/nceh
Infectious Disease Risks from Dead Bodies Following Natural Disasters	Pan American Journal of Public Health	A review of existing literature (circa 2004) to assess the risks of infection from dead bodies following a natural disaster, including who is most at risk, what precautions should be taken, and how to safely dispose of the bodies.	www.scielosp.org/article/rpsp/2004.v15n5/307-312
Mass Fatality Management of Incidents Involving Weapons of Mass Destruction	DoD and DOJ	Provides information for ME/Cs to establish fatality management strategies that mutually support and integrate key agencies in response activities. Focuses on the ME/C role, how to mobilize FSLTT resources, basic mass fatality management, handling contaminated remains, etc.	www.hsdl.org/?abstract&did=460809
Medical Examiner/ Coroner's Guide for Contaminated Deceased Body Management	American Journal of Forensic Medicine and Pathology	Provides information and suggestions for decontamination procedures, specifically developed for ME/C audience.	pubmed.ncbi.nlm.nih.gov/19901816

Resource	Source	Description	Link
Model Procedure for Medical Examiner/ Coroner on the Handling of a Body/Human Remains that are Potentially Radiologically Contaminated	Transportation Emergency Preparedness Program (TEPP)	Identifies precautions and provides guidance to ME/Cs on the handling of a body or human remains that are potentially contaminated with radioactive material from a transportation incident involving radioactive material.	www.hsdl.org/?view&did=764068
Mortuary Affairs in Joint Operations	DoD	Provides joint doctrine for mortuary affairs support in joint operations. Outlines procedures for search, recovery, evacuation (to include human remain tracking), tentative identification, processing, and/or temporary internment of remains.	www.fas.org/irp/doddir/dod/jp4_06.pdf
NCRP Report No. 161	National Council on Radiation Protection and Measurements (NCRP)	Offers guidance on handling persons contaminated with radionuclides.	ncrponline.org/publications/reports/ncrp-report-161
Standard Operating Procedures for Mass Fatality Management	National Association of Medical Examiners	An SOP for mass fatality management, including detailed information about scene responsibilities, incident morgues, family assistance centers, identification, death certification, training/exercises, etc.	www.thename.org/assets/docs/31434c24-8be0-4d2c-942a-8afde79ec1e7.pdf

Appendix 5.1: Impacted Populations

Chapter 4 provides guidance for handling patients who sustain major/critical injuries, such as severe burns and trauma. Evacuating critical patients must not be hindered by lengthy or restrictive decontamination and transport policies. For those who are not critically injured, decontamination instructions vary based on response actions and available resources/assistance:

Action Item

Include self-decontamination instructions in public education campaigns.

1. **Individuals who are directed to evacuate by emergency response officials** — These are individuals leaving the immediate impact zone (e.g., MDZ or LDZ zones) who may require assistance from responders to evacuate (e.g., search and rescue, emergency medical service). Some may be able to evacuate without responder assistance but as part of an organized immediate evacuation. These individuals may undergo preliminary screening at ad hoc screening locations. Emergency response officials must consult with radiation protection professionals regarding appropriate screening criteria and decontamination recommendations for these individuals that reflect the priorities and resources available.
2. **Individuals who are not directed to evacuate by emergency response officials but choose to self-evacuate of their own volition** — This includes individuals who self-evacuate before emergency responders arrive. Once responders arrive, there may be insufficient responders to direct everyone, and people may continue to self-evacuate. Responders will be unable to provide on-scene screening and decontamination assistance before these individuals evacuate and at best may direct them to an ad hoc screening location. Ideally, public education campaigns provide self-decontamination instructions to the public prior to emergency incidents. Even then, self-decontamination instructions must be provided to the public at ad hoc screening locations or through post-incident public outreach mechanisms. Planners should anticipate some of these individuals will be going directly to hospitals or seeking care in public shelters prior to being screened for contamination. Appendix 5.2: Strategies for Screening and Decontaminating People discusses special considerations for screening individuals arriving at shelters.

Coordination Opportunity

Emergency response officials must coordinate with radiation protection professionals at the state, local, and federal levels to develop screening criteria and decontamination recommendations. This includes state/local Radiation Control Program staff; the Advisory Team for Environment, Food and Health; ROSS; etc.

3. **Individuals who initially sheltered then evacuate as part of an organized evacuation** — It is assumed that these individuals have minimal levels of contamination upon evacuating.If feasible,

public messaging should include self-decontamination instructions prior to evacuation and subsequent screening at a CRC or shelter. As in the previous category, emergency response officials must make decontamination recommendations in collaboration with radiation protection professionals and share them with CRCs and shelters.

4. **Individuals in the area surrounding the detonation who have not received an evacuation notice but are concerned and seek screening to confirm that they have not been exposed or contaminated.** Despite being far from the impacted area, these individuals may report to hospitals or public shelters for contamination screening. This may represent a significant number of individuals, and planners must ensure they address this group's concerns. CRCs, as described in CDC's *Population Monitoring in Radiation Emergencies: A Guide for State and Local Public Health Planners*, address this population's needs as well as the displaced population's needs. Shelters are discussed in more detail in Chapter 4.

5. **Individuals that arrive at ports of entry following an incident in a foreign country.** It is assumed that these people were not screened upon departure and will need to be screened at the port of entry. Guidance on screening this population is available at www.radiationready.org/posted-tools/guidance-for-traveler-screening-at-ports-of-entry-following-an-international-radiological-incident.

- Self-evacuating individuals will require decontamination instructions through a public education campaign or through post-event public outreach mechanisms.
- Planning must include provisions for individuals who should remain safely sheltered but begin to request contamination screening to confirm that they have not been exposed or contaminated.

The public may self-evacuate using contaminated personal vehicles. Though this may result in the spread of contamination, it should not be discouraged during the initial days following a nuclear detonation. More information about this can be found in the evacuation discussion in Chapter 3.

In communities where English is not the primary language, instructions should be provided in languages appropriate for the affected community. Additionally, instructions must be accessible for people with disabilities or access and functional needs. After the initial response, more detailed instructions and PAG should be provided to mitigate contamination, dose, and residual risk.

Action Item

Prepare instructions in every language spoken within your community.

Appendix 5.2: Strategies for Screening and Decontaminating People

Radiation Screening

- Screening and decontamination staff must communicate clearly and accessibly to ensure people arriving at CRC and shelters understand the intake process and what is expected of them.
- Because of limited screening and decontamination resources, these services must be prioritized for people, followed by service animals. Resources should not be devoted to screening and decontaminating personal possessions and pets at the expense of screening and decontaminating people.
- During screening and decontamination, CRC and shelter workers must use appropriate PPE to minimize the spread of contamination.
- Additional assistance should be provided for people with disabilities, functional needs, or access needs.
- Dependents should not be separated from their caregivers.

While this section describes screening people for radioactive contamination, people arriving at the shelter should also undergo a quick medical screening to identify health issues that may require treatment or referral. For life-threatening or severe injuries, medical care takes priority over contamination screening and decontamination.

If CRCs are available:

- People who come to the shelter before going to a CRC could be directed to a CRC for initial screening and decontamination, if feasible.
- People who come to the shelter after processing through a CRC must have CRC discharge paperwork, or some other form of documentation, that can be reviewed by shelter staff to confirm appropriate screening and decontamination occurred at the CRC. If such documentation is not available, people should be re-screened and self-decontaminate upon arrival at the shelter.

In some cases, CRCs may release people with detectable levels of contamination on their skin or clothes. These levels will not be harmful to them or others around them. However, if resources are available at the shelter, those people may clean themselves or change clothes and shoes to further reduce their levels of contamination.

Appendix 5.3: Screening and Decontaminating Service Animals and Pets

Experience from past disasters has shown that when people have to evacuate their homes, they most likely take their pets or service animals with them. In fact, the federal government advises pet owners against leaving pets behind if they ever have to evacuate their homes (FEMA, 2021a).

Action Item

Ensure plans include provisions for handling service and companion animals.

Planners should consult with veterinarians regarding how to handle animals at CRCs, assembly centers, evacuation centers, etc. Exercises should include service and companion animals to ensure plans are tested.

In the U.S., the number of pet dogs and cats alone exceeds 150 million (American Veterinary Medical Association, 2017). In a nuclear emergency, pets accompanying their owners present a challenge to response and relief organizations as pet evacuation, decontamination, and sheltering have to be considered along with people evacuation, decontamination, and sheltering. The Pet Evacuation and Transportation (PETS) Act of 2006 requires that state and local emergency plans address the needs of people with household pets or service animals (Public Law 109-138, 2005).

A thorough cleaning of animals can present a challenge because there is no layer of clothing to take off and animals with long hair are more difficult to clean. As with people, any action to dust off and partially remove contamination is helpful. When brushing animals, care should be taken to avoid inhaling any particulates. Using a dust mask and brushing the animals outside and upwind may be appropriate. When possible, bathing and grooming thoroughly can remove additional contamination.

At CRCs, areas can be designated for pet owners to clean their own animals, as this will reduce anxiety for the animals and speed up the process. To the extent possible, assistance should be provided to those unable to clean their animals themselves. For those unable to report to a CRC, instructions for cleaning pets should be provided with instructions for self-decontamination.

Animals may re-contaminate themselves and bring contamination inside homes or shelters. At CRCs or public shelters, animal spaces are usually restricted. For people sheltering at home, communications should address placing pets in cages or on a leash if there is risk of re-contamination after washing. Animals cross-contaminating owners, especially children who pet them, present a health risk. Communications should also target veterinary professionals to ensure they provide appropriate advice and services to clients whose animals may have been contaminated or received harmful levels of radiation exposure.

Coordination Opportunity

Incident management officials must coordinate with veterinary professionals to ensure contaminated animals are treated appropriately.

Appendix 5.4: Handling Contaminated Vehicles

Fallout-contaminated vehicles can spread contamination outside of the damage and hazard zones. Vehicle decontamination can mitigate the spread of contamination but should not restrict or inhibit evacuations. Use of contaminated vehicles (personal or mass transit) for evacuation should not be discouraged in the initial days following a nuclear detonation because cross-contamination issues are a secondary concern.

Vehicle Contamination Screening

The initial step of vehicle decontamination is vehicle screening to determine the extent of contamination. If vehicles are leaving a known contaminated area (e.g., evacuating from the HZ), initial screening may be skipped in favor of immediate decontamination, assuming sufficient decontamination resources are available. Screening areas should have low levels of background radiation (less than 0.3 μSv/hr) to ensure positive readings are attributable to the vehicles. To accommodate high-yield nuclear detonations, staging areas should be capable of containing many vehicles. In urban areas with high population density, tens of thousands of acres may be necessary to store millions of vehicles—roughly 184 vehicles per acre.

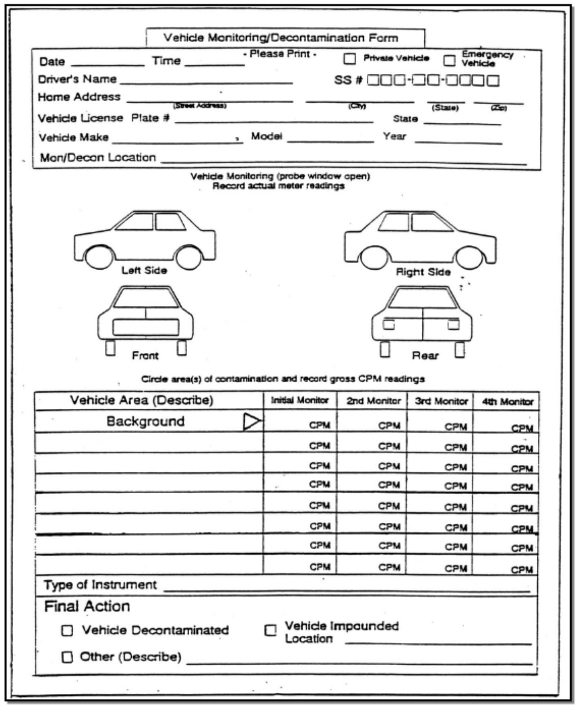
Refer To

Screening processes will vary, depending on resource availability. Information regarding different screening procedures can be found in the following resources:

- *Using Preventative Radiological Nuclear Detection Equipment for Consequence Management (2017):* www.dhs.gov/publication/st-frg-using-preventative-radiological-nuclear-detection-equipment-consequence
- *Arizona Department of Public Health's Radiological Emergency Response Plan:* *www.azdhs.gov/documents/preparedness/emergency-preparedness/response-plans/radiological-emergency-response-plan.pdf*
- *Multiservice Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Contamination Avoidance: irp.fas.org/doddir/army/fm3-11-3.pdf*

Vehicle screening requires radiation detection instruments. While ideally, the entire vehicle should be screened, in the early phases of the evacuation responders may just screen wheel wells, vehicle grill, and interior floors. Planners should coordinate with radiological/nuclear SMEs to determine which instruments and methods to include in their plans, as well as coordinate with FSLTT organizations to determine availability.

As vehicles leave the screening and decontamination area, planners should ensure that they are not re-screened or re-decontaminated, wasting resources needed elsewhere. Keeping a record of vehicle screening and decontamination helps mitigate this issue. Plans must specify record-keeping practices, capturing information such as the vehicle's VIN number, license plate number, level of contamination on various parts of the vehicle, screening instrument used, name of person conducting screening, and any additional decontamination instructions for the owner. An example vehicle screening form can be seen below in Figure 53. Planners should also consider digital record-keeping options and develop contingency plans, depending on electronic equipment availability.



Vehicle Monitoring/Decontamination Form

- Please Print -

Date ________ Time ________ ☐ Private Vehicle ☐ Emergency Vehicle

Driver's Name ________________ SS # ☐☐☐-☐☐-☐☐☐☐

Home Address ________________ (Street Address) ________ (City) ____ (State) ____ (Zip)

Vehicle License Plate # ________________ State ________

Vehicle Make ____________, Model ________ Year ________

Mon/Decon Location ________________________________

Vehicle Monitoring (probe window open)
Record actual meter readings

Circle area(s) of contamination and record gross CPM readings

Vehicle Area (Describe)	Initial Monitor	2nd Monitor	3rd Monitor	4th Monitor
Background ▷	CPM	CPM	CPM	CPM
	CPM	CPM	CPM	CPM
	CPM	CPM	CPM	CPM
	CPM	CPM	CPM	CPM
	CPM	CPM	CPM	CPM
	CPM	CPM	CPM	CPM
	CPM	CPM	CPM	CPM
	CPM	CPM	CPM	CPM

Type of Instrument ________________________________

Final Action

☐ Vehicle Decontaminated ☐ Vehicle Impounded Location ________

☐ Other (Describe) ________________________________

Figure 53: Example Vehicle Screening Form

Vehicle Decontamination

If a vehicle exhibits unacceptable levels of radiological contamination (to be determined by the authority having jurisdiction), decontamination is recommended. Wet and dry decontamination methods are available for decontaminating the interior and exterior of vehicles.

DRY DECONTAMINATION

Vehicle dry decontamination with HEPA vacuums is effective on non-porous surfaces, particularly fabric and seats in vehicle interiors. Spray-and-vacuum technologies are also available for vehicle interior decontamination, wherein a powdery substance is sprayed throughout the vehicle (particularly in delicate or inaccessible components), then vacuumed after about 30 minutes of absorption. These tools may not be widely available, so planners must include access methods throughout their plans if they intend to use them.

WET DECONTAMINATION

Wet decontamination is more effective for non-porous surfaces and consists of applying detergent with long-handled brushes, to remove contaminated dust, mud, and debris. Additionally, spraying

60–120 psi water for 2–3 minutes can effectively decontaminate vehicle exteriors. Some advanced wet decontamination tools are available and may be more effective than water alone, but these may not be readily available, so planners must include access methods in plans.

Wet decontamination sometimes involves large volumes of water, so planners must consider water resource availability when determining appropriate decontamination methods. If possible, sump pumps should be used to collect contaminated run-off water from wet decontamination methods. However, if resources are strained or unavailable, run-off water can be allowed to soak into the ground.

Vehicles that exhibit acceptable levels of radiation following decontamination should be returned to their owners, if possible, but may require long-term storage, depending on the owner's status (evacuated, injured, deceased, etc.). Vehicles that continue to exhibit unacceptable levels of contamination may be subject to additional rounds of decontamination if resources allow. At a minimum, vehicles that remain contaminated must be segregated from successfully decontaminated vehicles to prevent cross-contamination. In all cases, planners must anticipate storing potentially large numbers of decontaminated vehicles.

Non-Response Vehicle Decontamination

Planners must coordinate with PIOs to prepare messaging that describes simple decontamination methods for the public. Evacuees may utilize their unscreened vehicles to evacuate, but a simple decontamination method, such as rinsing with soap and water, can minimize the spread of contamination.

Disabled Vehicles

While vehicle contamination will vary based on fallout, there will be many disabled/abandoned vehicles in any nuclear detonation scenario both inside the damage zones and outside of them (e.g., resulting from accidents caused by flash blindness). Disabled/abandoned vehicles will impede evacuation and response activities by blocking ingress/egress routes, so removal operations are critical. Local governments should consider identifying, pre-qualifying, and/or pre-establishing contracts with heavy-duty towing companies and storage resources.

Appendix 5.5: Resources to Support Contamination Screening Activities

Radiological Operations Support Specialists (ROSS)

If there is a major incident, there will be a need to supplement the existing pool of radiation professionals in impacted and surrounding communities. The ROSS, a NIMS-typed FEMA-certified position, was created for this purpose. ROSS are trained to assist incident management anywhere radiation protection expertise is needed. ROSS can assess the situation by interpreting data and providing actionable guidance for decision makers.

ROSS are prepared for the worst NPP releases, radiological dispersal devices (RDD) or transportation accidents, as well as a nuclear detonation. They are trained to interpret radiological release models and dose projections and provide situational awareness and environmental data management using RadResponder. ROSS are also trained to deliver concise but comprehensive guidance as required in an incident command structure, design and implement just-in-time training, and develop and manage environmental sampling plans that meet data quality objectives. They serve their local Radiation Control Program and emergency preparedness agency and can be requested from unaffected jurisdictions as mutual aid.

Volunteer Radiation Professionals

As stated in the National Response Framework (NRF), population decontamination activities are accomplished locally and are the responsibility of local and state authorities (FEMA, 2019b). Federal resources to assist with population monitoring and decontamination are limited and will take some time to arrive. Radiation control staff employed by local and state governments are few in number. However, other radiation protection professionals can volunteer and register with the Citizen Corps programs in their community. Specifically, the Medical Reserve Corps can recruit and train radiation professionals to assist public health and emergency management agencies with population monitoring or shelter support operations.

Refer To

- Citizen Corps website: www.ready.gov/citizen-corps
- Medical Reserve Corps website: www.phe.gov/mrc/Pages/default.aspx

The ESAR-VHP[58] establishes and implements guidelines and standards for registering, credentialing, and deploying medical professionals for response to large-scale national emergencies. The same system can be used to recruit and register radiological health professionals (e.g., health physicists, medical physicists, radiation protection technologists, nuclear medicine technologists, nuclear engineers, etc.) for response to nuclear emergencies. Another resource available to several states is the Radiation Response Volunteer Corps (RRVC), a program developed by the CRCPD with support from CDC.

Refer To

- ESAR-VHP page on the Public Health Emergency (PHE) website: www.phe.gov/esarvhp/Pages/about.aspx
- RRVC page on the CRCPD website: www.crcpd.org/page/RRVC

Mutual Aid Programs

Many states, especially those with NPPs, have established mutual aid agreements with nearby states to aid in radiation emergencies. The EMAC is a congressionally ratified organization that provides form and structure to interstate mutual aid and addresses key issues, such as liability and reimbursement. Through EMAC, a disaster-impacted state can request and receive assistance from another member state quickly and efficiently.

Some radiation control programs have formed compacts to provide mutual aid for radiological emergencies, such as the New England Radiological Health Protection Compact and the Mid-Atlantic States Radiation Control Compact. Consult your Radiation Control Program to find out if your state is a member of a compact.

Refer To

EMAC website: www.emacweb.org

CRC SimPLER

CRC SimPLER helps radiation emergency planners understand their current capacity, potential bottlenecks, and additional resource needs when planning for population monitoring during response to a radiation emergency. It focuses on typical or anticipated activities that are needed to

[58] The ESAR-VHP program is administered under the Assistant Secretary for Preparedness and Response (ASPR) within the Office of Preparedness and Emergency Operations of DHHS (www.phe.gov/esarvhp/pages/about.aspx).

conduct population monitoring, which include but are not limited to providing services such as basic first aid, contamination screening, decontamination, registration, and mental health counseling. This program helps planners assess their current population-monitoring capacity and plan for potential needs in a way that is simple to understand, quick to interpret, and can be taken or presented to decision makers if/when they need to ask for additional resources. This software can also be used as a training tool for locations that are beginning to form population-monitoring plans and those who have not yet conducted CRC full-scale exercises. CRC SimPLER was developed using modelling software and incorporates real timing data collected from CRC exercises across the country.

Refer To

CRC SimPLER is available at ephtracking.cdc.gov/Applications/simPler/home.

To request simPLER training and assistance, reach out to simpler@CDC.gov.

Appendix 5.6: Available Tools for Tracking and Monitoring People

Several electronic tools are available for planners to determine how they will track and monitorthe population following a radiological incident. These tools can be used to gather and assess data, although they may require more staff and training to utilize. A brief description of these tools follows. Additional training is available for these tools.

The CRC Electronic Data Collection Tool (CRC eTool)

www.cdc.gov/nceh/radiation/emergencies/crcetool.htm

The CRC eTool is designed to collect, analyze, visualize, and securely exchange population-monitoring data, including demographics, radiation contamination measurements, radiation exposure assessment, and health outcomes. It was created using the Epi Info™ platform and can be implemented using local networks to include laptops, tablets, and cellphones. Data analysis, visualization, and transfer and exchange processes are much more efficient once data are collected electronically.

Epi Info™ is a free platform that is commonly used by public health professionals for data collection, statistical analysis, and data visualization. It is a public domain suite of interoperable software tools designed for the global community of public health practitioners and researchers. It provides a data entry form and database construction, a customized data entry experience, and data analyses with epidemiologic statistics, maps, and graphs for public health professionals who may lack an information technology background.

Planners should set up eTool and Epi Info™ prior to an incident if they intend to use either. Setup may require IT support.

Rapid Response Registry (RRR)

www.atsdr.cdc.gov/rapidresponse/#tools

ATSDR's RRR survey instrument gives local and state entities a tool to register responders and others exposed to or contaminated with chemical, biological, or radiological materials from a disaster. The survey instrument is a two-page form that can be distributed on paper or electronically. It can be implemented quickly to collect basic information rapidly to identify and locate victims and displaced people. Information collected by the RRR survey instrument can be used to:

- Support real-time needs assessment during an emergency affecting public health.
- Assess future medical assistance, health intervention, and health education needs.

- Contact enrolled individuals with information regarding exposures, adverse health impacts, health updates, available educational materials, and follow-up services.

Key information to collect includes:

- Demographics (name, age, sex, home address, status, and place of employment)
- Health information
- Exposure information
- Exposure-related health effects
- Immediate health and safety needs
- Health insurance

For mass casualty incidents, the four critical fields below are sufficient to establish an official registry record:

- Name
- Sex
- Address
- Contact information (telephone and email)

Epi CASE (Contact Assessment Symptom Exposure) Toolkit

www.atsdr.cdc.gov/epitoolkit/index.html

The Epi CASE toolkit gives local and state public health and disaster response agencies a way to rapidly assesspersons who are affected by, exposed to, or potentially exposed to CBRN or other harmful agents during incidents.The toolkit can also aid public health professionals developing a health registry. Registries are a large time and resource commitment, so careful consideration is necessary. These tools can help guide those decisions.

Data collected through the toolkit can generate simple descriptive statistics. This information also can be used as for epidemiologic follow-up, including health studies, community assessments, health assessments, and health registries. The Epi-CASE toolkit is modeled after the Rapid Response Registry toolkit to help public health professionals make quick assessments.

The ERHMS System

www.cdc.gov/niosh/erhms

The ERHMS system is a health monitoring and surveillance framework that includes recommendations and tools to protect emergency responders during all phases of a response, including pre-deployment, deployment, and post-deployment phases. ERHMS principles apply to both small- and large-scale incidents, including local-, state-, and federal-level responses.

ERHMS supports many activities relevant to responder health monitoring:

- Identifying exposure and/or signs and symptoms early in the course of an emergency response.
- Preventing or mitigating adverse physical and psychological outcomes.
- Ensuring workers maintain their ability to respond effectively and are unharmed.
- Evaluating protective measures.
- Identifying responders for medical referral and possible enrollment in long-term health surveillance programs.

ERHMS covers the following activities for each phase of deployment:

PRE-DEPLOYMENT PHASE:

- Rostering and credentialing of emergency response and recovery workers
- Health screening for emergency responders
- Health and safety training
- Data management and information security

DEPLOYMENT PHASE:

- On-site responder in-processing
- Health monitoring and surveillance during response operations
- Integration of exposure assessment, responder activity documentation, and control
- Communications of exposure and health monitoring and surveillance data during an emergency response

POST-DEPLOYMENT PHASE:

- Responders out-processing assessment
- Post-event tracking of emergency responder health and function

- Lessons-learned and after-action assessments

Acronyms

A&W	Alert & Warning
ADA	Americans with Disabilities Act
AFRRI	Armed Forces Radiobiology Research Institute
AGL	Above Ground Level
ALARA	As Low As Reasonably Achievable
AM/FM	Amplitude Modulation/Frequency Modulation
AMBER	America’s Missing: Broadcast Emergency Response
ANSI	American National Standards Institute
AOSP	Alert Origination Software Provider
AOT	Alert Origination Tools
ARS	Acute Radiation Syndrome
ASPR	Assistant Secretary for Preparedness and Response
ATSDR	Agency for Toxic Substances and Disease Registry
AWN	Alerts, Warning, and Notifications
CAP	Common Alerting Protocol
CBC	Complete Blood Count
CBRN	Chemical, Biological, Radiological, and Nuclear
CDC	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
COG ID	Collaborative Operating Group Identification
COLTs	Cell on Light Trucks
COOP	Continuity of Operations

COP	Common Operating Picture
COWs	Cell on Wheels/Wings
CPM	Counts per Minute
CRC	Communication Reception Center
CRCPD	Conference of Radiation Control Program Directors
CROW	Cellular Repeater on Wheels
CRS	Cutaneous Radiation Syndrome
DBS	Direct Broadcast System
DFZ	Dangerous Fallout Zone
DHS	Department of Homeland Security
DIME	Delayed, Immediate, Minimal, and Expectant
DIS	Direct-Ion Storage
DOC	Department of Commerce
DoD	Department of Defense
DOE	Department of Energy
DRZ	Dangerous Radiation Zone
EAS	Emergency Alert System
EAST	Exposure and Symptom Triage
EC	Evacuation Center
EMAC	Emergency Management Assistance Compact
EMP	Electromagnetic Pulse
EMS	Emergency Medical Services
EOC	Emergency Operations Center
EPA	Environmental Protection Agency

EPD	Electronic Personal Dosimeter
Epi CASE	Epi Contact Assessment Symptom Exposure
ERHMS	Emergency Responder Health Monitoring and Surveillance
ESAR-VHP	Emergency System for Advance Registration of Volunteer Health Professionals
ESF	Emergency Support Function
ETN	Enhanced Telephone Notification
eTool	Electronic Data Collection Tool
EUA	Emergency Use Authorization
FAOC	FEMA Alternate Operations Center
FCC	Federal Communications Commission
FDA	US Food and Drug Administration
FEMA	Federal Emergency Management Agency
FIOPs	Federal Interagency Operational Plans
FMS	Federal Medical Stations
FOC	FEMA Operations Center
FSLTT	Federal, State, Local, Tribal, and Territorial
GI	Gastrointestinal
GM	Geiger-Mueller
GMD	Geomagnetic Disturbance
GOAT	Generator On A Trailer
HAN	Health Alert Network
H-ARS	Hematopoietic Subsyndrome of ARS
HAZMAT	Hazardous Materials
HEMP	High-Altitude Electromagnetic Pulse

HHS	US Department of Health and Human Services
HICS	Hospital Incident Command System
HOB	Height of Burst
HZ	Hot Zone
IAEA	International Atomic Energy Agency
ICS	Incident Command System
IMAAC	Interagency Modeling Assessment and Atmospheric Center
IMAT	Incident Management Assistance Team
IND	Improvised Nuclear Device
IPAWS	Integrated Public Alert & Warning System
IPAWS-OPEN	Integrated Public Alert and Warning System Open Platform for Emergency Networks
JIC/JIS	Joint Information Center/Joint Information System
kT	Kiloton
LDZ	Light Damage Zone
LLNL	Lawrence Livermore National Laboratory
MC	Medical Center
MDZ	Moderate Damage Zone
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
NAWAS	National Warning System
NCRP	National Council on Radiation Protection and Measurements
NDAA	National Defense Authorization Act
NECP	National Emergency Communications Plan
NGO	Non-Governmental Organization

NIMS	National Incident Management System
NIOSH	National Institute for Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Administration
NORAD	North American Aerospace Defense Command
NPP	Nuclear Power Plant
NPR	National Public Radio
NPS	National Planning Scenario
NPWS	National Public Warning System
NRC	Nuclear Regulatory Commission
NRF	National Response Framework
NRIA	Nuclear/Radiological Incident Annex
NTS	Nevada Test Site
NWEM	Non-Weather Emergency Messages
NWR	NOAA Weather Radio
NYC	New York City
OASIS	Organization for the Advancement of Structured Information Systems
OSL	Optically Simulated Luminescence
PAGs	Protective Action Guides
PCO	President’s Communications Officer
PEP	Primary Entry Point
PRD	Personal Radiation Detectors
PETS	Pets Evacuation and Transportation Standards
PIO	Public Information Officer
PL	Public Law

PMO	Program Management Office
PODs	Points of Dispensing
PPE	Personal Protective Equipment
PRD	Personal Radiation Detector
PSAP	Public Safety Answering Points
PSI	Pounds per Square Inch
RDD	Radiological Dispersal Device
REAC/TS	Radiation Emergency Assistance Center/Training Site
REC	Regional Emergency Coordinators
REMM	Radiation Emergency Medical Management
REP	Radiological Emergency Preparedness
RESRAD	Residual Radioactivity
RITN	Radiation Injury Treatment Network
ROSS	Radiological Operations Support Specialist
RRR	Rapid Response Registry
RRVC	Radiation Response Volunteer Corps
RTR	Radiation Triage, Treatment, and Transport
RWT	Required Weekly Test
SALT	Sort, Assess, Lifesaving Interventions, Treatment/Transport
SDZ	Severe Damage Zone
SECC	State Emergency Communications Committees
SIP	Shelter-In-Place
SLTT	State, Local, Tribal, and Territorial
SMS-CB	Short Message Service—Cell Broadcast

SMS-PP	Short Message Service—Point to Point
SNS	Strategic National Stockpile
SOP	Standard Operating Procedure
SPD	Surge Protection Device
SREMP	Source Region Electromagnetic Pulse
START	Simple Triage and Rapid Treatment
SWP	State Warning Point
TBSA	Total Body Surface Area
TEPP	Transportation Emergency Preparedness Program
TLD	Thermoluminescent Dosimeter
TNT	Trinitrotoluene
TRACIE	Technical Resources, Assistance Center, and Information Exchange
UMI	User-Managed Inventories
UPS	Uninterruptable Power Supply
US	United States
NORTHCOMM	Northern Command
VHF	Very High Frequency
WEA	Wireless Emergency Alert
WHCA	White House Communications Agency
XML	Extensible Markup Language

Definitions [59]

Activity – Measure of the frequency of radioactive decay in a substance, corresponding to the amount of radiation emitted. Units include becquerel and curie.

Adequate shelter – Shelter that protects against acute radiation effects and significantly reduces radiation dose to occupants during an extended period. Shelters that reduce external radiation exposure by a factor of 10 or more are considered adequate.

ALARA (As Low As Reasonably Achievable) – A principle to control or manage radiation exposure to individuals and releases of radioactive material to the environment so that doses are "As Low As Reasonably Achievable"—that is, as low as social, technical, economic, practical, and public welfare considerations permit.

Ambulatory – Victims who are able to walk to obtain medical care.

Becquerel -- the SI unit of radioactivity, corresponding to one disintegration per second.

Beta burn – Beta radiation–induced skin damage.

Blast effects – The impacts caused by the shock wave of energy through air that is created by detonation of a nuclear device. The blast wave is a pulse of air in which the pressure increases sharply at the front and is accompanied by winds.

Combined injury – Victims of the immediate effects of a nuclear detonation are likely to suffer from burns and/or physical trauma, in addition to radiation exposure.

Community Reception Center (CRC) – Locations/facilities in impacted areas, designed to screen, decontaminate, and register people.

Curie -- a unit of radioactivity, corresponding to 3.7×10^{10} disintegrations per second.

Dose – Radiation absorbed by an individual's body; general term used to denote mean absorbed dose, equivalent dose, effective dose, or effective equivalent dose, and to denote dose received or committed dose.

Duck and Cover – A suggested method of personal protection against the effects of a nuclear weapon that the United States government taught to generations of school children from the early 1950s into the 1980s. The technique was supposed to protect them during an unexpected nuclear attack that, they were told, could come at any time without warning. Immediately after they saw a flash, they had to stop

[59] When available, definitions have been adapted from Glasstone & Dolan, 1977 or the Department of Homeland Security (DHS) Planning Guidance (FEMA, 2008).

what they were doing and get on the ground under some cover, such as a table or against a wall, and assume the fetal position, lying face down and covering their heads with their hands.

Electromagnetic Pulse (EMP) – A sharp pulse of radiofrequency (long wavelength) electromagnetic radiation produced when an explosion occurs near the Earth's surface or at high altitudes. The intense electric and magnetic fields can damage unprotected electronics and electronicequipment over a large area.

Emergency Management Assistance Compact (EMAC) – A congressionally ratified organization that provides form and structure to interstate mutual aid. Through EMAC, a disaster-affected state can request and receive assistance from other member states quickly and efficiently, resolving two key issues up front: liability and reimbursement.

Dose Rate – The radiation dose absorbed per unit of time. Generally, radiation doses received over a longer period of time are less harmful than doses received instantaneously.

Fallout – The process or phenomenon of the descent to the Earth's surface of particles contaminated with radioactive material from the radioactive cloud. The term is also applied in a collective sense to the contaminated particulate matter itself.

Firestorms – A large and destructive fire that creates its own wind system. The firestorm's winds come from all directions, coalescing towards a center where the heated air ascends.

Fission Products – Radioactive subspecies resulting from the splitting (fission) of the nuclei of higher-level elements (e.g., uranium and plutonium) in a nuclear weapon or nuclear reactor.

LD50 – The amount of radiation that kills 50% of a sample population.

Morbidity – A diseased state or symptom, the incidence of disease, or the rate of sickness.

Mortality – A fatal outcome or, in one word, death. Also, the number of deaths in a given time or place or the proportion of deaths to population.

Personal Protective Equipment (PPE) – Includes all clothing and other work accessories designed to create a barrier against hazards. Examples include safety goggles, blast shields, hard hats, hearing protectors, gloves, respirator, aprons, and work boots.

rad – A unit expressing the absorbed dose of ionizing radiation. Absorbed dose is the energy deposited per unit mass of matter. The units of rad and Gray are the units in the traditional and SI systems for expressing absorbed dose.

Radiation effects – Impacts associated with the ionizing radiation (alpha, beta, gamma, neutron,etc.) produced by or from a nuclear detonation, including radioactive decay.

Radiation Triage, Treatment, and Transport (RTR) – A series of pre-designated and ad hoc, self-organizing locations for triaging, organizing, transporting, or treating people requiring medical attention, as needed.

Radioactivity – The emission of radiation caused by the spontaneous disintegration ("decay") of atomic nuclei.

rem – A unit of equivalent dose that accounts for both the energy deposited per unit mass (absorbed dose) and the relative biological effectiveness of ionizing radiations in tissue. Not all radiation produces the same biological effect, even for the same amount of absorbed dose; rem relates the absorbed dose in human tissue to the effective biological damage of the radiation. The units of rem and Sievert are the units in the traditional and SI systems for expressing equivalent dose.

Roentgen (R) – A unit of gamma or x-ray exposure in air. For the purpose of this guidance, one R of exposure is approximately equal to one rem of whole-body external dose.

Roentgen per hour (R/h) – A unit used to express gamma or x-ray exposure in air per unit of time (exposure rate).

Shelter – To take "shelter" as used in this document means going in, or staying in, any enclosed structure to escape direct exposure to fallout. "Shelter" may include the use of pre-designated facilities or locations. It also includes locations readily available at the time of need, including staying inside where you are or going immediately indoors in any readily available structure.

Shelter-in-place – Staying inside or going immediately indoors in the nearest yet most protective structure.

Survivable victim – An individual that will survive the incident if a successful rescue operation is executed and likely will not survive the incident if the rescue operation does not occur.

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