Enhancing Personal Readiness and Resilience for

Radiation Disasters

A Guide for all Citizens

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Preface

Local citizens are the ultimate stakeholders in disaster response and are an integral part of national preparedness efforts. Citizen preparedness, like emergency response, needs to be rooted in strong local efforts to engage citizens to address each community's unique risks and capabilities. In a disaster, individuals and communities may deal with an immediate demand for medical resources, especially in rural areas and during severe mass casualty events in which local emergency medical services (EMS) and hospitals are overwhelmed. In such situations, citizens are known to arrive first at the scene to rescue survivors or provide care for injured and displaced persons. Citizen responders can be a valuable and much needed resource for providing immediate assistance, especially when rapid intervention may be critical to survival.

In December 2009, the *National Health Security Strategy* was released with stated goals of building community resilience and strengthening national health and emergency response systems. An essential means for achieving these goals is through the creation of an informed and empowered population, with the social networks and health systems to help residents cope with tragedy. In a disaster, empowered individuals have the information and skills they need to protect their health and safety, and mobilize an appropriate "bystander response" until help arrives. In preparation for a disaster, citizens need access to meaningful and constructive training in basic skills they can use to assist themselves and others. They must be able to recognize and protect themselves from potential hazards, know how and when to call for help, be willing and able to safely intervene without disrupting organized response efforts, and know how to provide critical life support. Prior to and following the arrival of EMS personnel, well-prepared citizens with documented training can make a positive contribution if they understand what is expected of them and what their role is in the response system.

This *Radiation Disaster Guide* is intended to help attain national health security goals by providing critical medical and mental health information to enable individual citizens to play a more effective role in local disaster preparedness and response efforts. The *Guide* provides citizens with basic life-saving and support information that can be applied in a radiation emergency during the first hours or days following the event when emergency medical and 911 systems are likely to be overwhelmed and thus unable to attend to all injured or ill people; when there are so many casualties that choices have to be made on treatment options; and during situations in which usual medical care services are not available. The *Guide* addresses the injuries and conditions most likely to occur in a radiation emergency and teaches the most essential and basic protective actions that can be taken by almost everyone and that are necessary to save lives and prevent further injury and harm; particularly when community emergency resources are severely stressed.

1.0 Purpose

To educate citizens about the effects of a radiation disaster and how they can protect themselves and others from harm.

2.0 Learning Objectives

After reading this *Guide*, citizens will be able to:

- Describe the types and characteristics of ionizing radiation.
- Identify possible radiation threats in the community and workplace.
- Describe possible health effects of radiation exposure.
- Describe actions individuals can take to prepare for a radiation disaster.
- Describe actions individuals can take during and after a radiation disaster.

3.0 Radiation Basics

Radiation affects all of us, every day, as result of being on this planet. All living things have evolved with exposure to naturally occurring radiation from the earth and sun. Most of us also have encountered human-created radiation, such as that received from medical and dental x-rays. Radiation is used to diagnose various ailments and some people are treated with radiation to cure disease. We all benefit from products and services made possible by the careful use of radioactive materials.

The longer a person is exposed to radiation, the greater the effect. A high exposure to radiation can cause serious illness or death. Radiation provokes a special fear but, with appropriate understanding and preparation, effective precautions and care can be provided to exposed people. It can be detected easily with equipment found in many hospitals, and carried by most fire departments and other emergency response personnel.

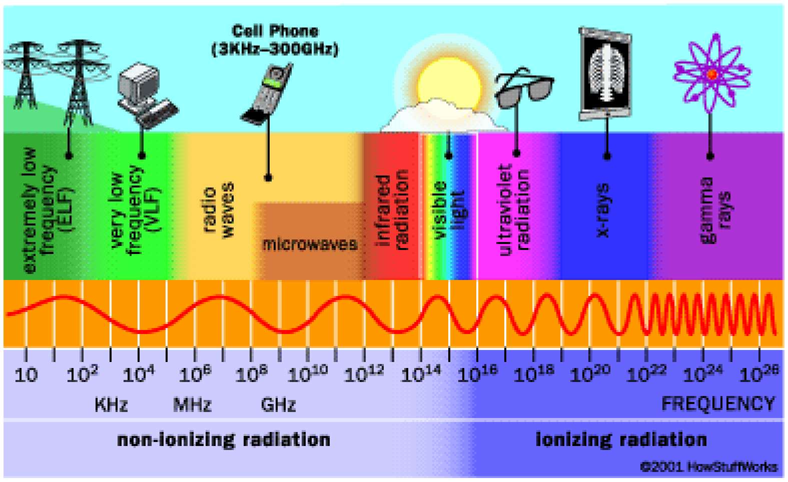
3.1 Ionizing Radiation

Radioactive materials are composed of atoms that are unstable, which causes them to give off a form of energy that travels in waves or particles. An unstable atom gives off (or emits) its excess energy or mass until it becomes stable. These emissions are called radiation, or more accurately, ionizing radiation. Ionizing radiation is high-frequency radiation that has enough energy to remove an electron from (ionize) an atom or molecule. The radiation is emitted as electromagnetic waves (like light) and particles (ie, mass given off with the energy of motion).

Radioactivity is the property of some atoms to give off energy in the form of particles or rays. Different types of radiation exist, some of which have more energy than others.

Ionizing radiation has many uses, including killing cancer cells and generating electric power. Although ionizing radiation has many applications, overexposure can be hazardous to human health. The largest use of ionizing radiation in medicine is in medical radiography to make images of the inside of the human body using x-rays. This is the largest artificial source of radiation exposure for humans. Radiation is also used to treat diseases in radiation therapy. Tracer methods are used in nuclear medicine to diagnose diseases, and are widely used in biologic research. In biology and agriculture, radiation is used to induce mutations to produce new or improved species, as well as for pest control (male insects can be sterilized by radiation and released, so they have no offspring, thus reducing the insect population). In industrial and food applications, radiation is used for the sterilization of tools and equipment. An emerging use is the sterilization of food products using irradiation.

Figure 3-1. Electromagnetic Spectrum



3.2 Non-Ionizing Radiation

Non-ionizing radiation is low-frequency radiation that does not have enough energy to remove electrons from atoms or directly damage cell DNA. Low-energy ultraviolet (UV) rays, visible light, infrared rays (such as those used in “heat” lamps to keep food warm in restaurants), microwaves, and radio waves are all forms of non-ionizing radiation. Non-ionizing radiation given off by a cell phone or a television screen is not the same as the ionizing radiation you might get from x-rays taken in the hospital. Low-energy non-ionizing radiation may damage molecules, but the effect is generally indistinguishable from the effects of simple heating.

3.3 Types of Ionizing Radiation

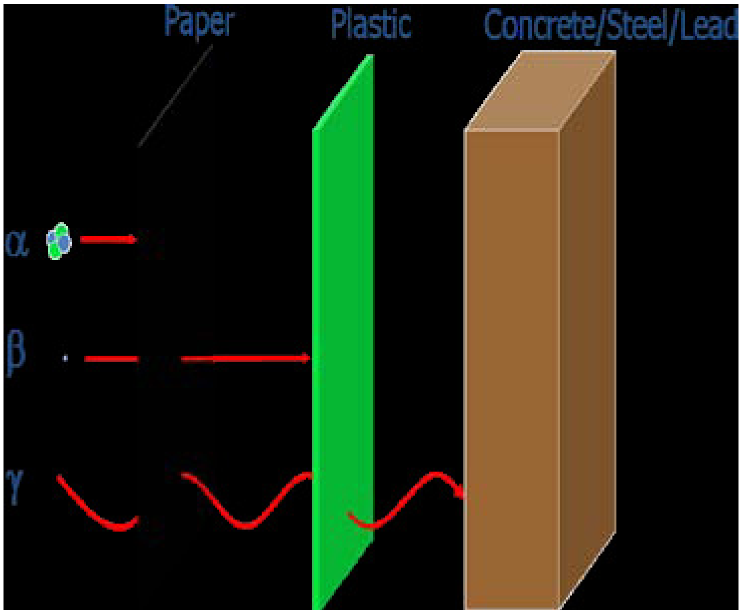
The potential health effects of ionizing radiation depend, in part, on the characteristics of the radiation. The three principle types of ionizing radiation are described below:

Alpha (α) particles can be stopped by a thin layer of light material, such as a sheet of paper, and cannot penetrate the outer, dead layer of skin. They do not pose a hazard as long as they are outside the body. Radioactive materials that emit alpha particles are an internal hazard if ingested or inhaled.

Beta (β) particles travel only a few feet in air and can be stopped by a thin sheet of aluminum. Beta particles can penetrate the outer layers of skin and are both an external and internal hazard. Beta radiation travels only a short distance in tissue, depending on its energy, and can be a significant source of dose to the skin.

Gamma (γ) radiation is very difficult to shield against. Unlike alpha or beta particles, gamma rays are electromagnetic energy similar to x-rays. Concrete, lead, or steel is needed to shield sources of gamma rays. High-energy gamma radiation can penetrate deeply into tissue. Most radioactive materials with current commercial applications emit high-energy gamma rays.

Figure 3-2. Comparative Energy Levels of Particle and Wave Forms of Ionizing Radiation



Another radiation hazard arises when <u>neutrons</u> impact materials such as metal, soil, rock, and buildings that are in close proximity to ground zero during a nuclear detonation. The absorption of neutrons in these materials can make them radioactive, emitting beta and gamma radiation.

3.4 Detection and Measurement of Radioactivity

To many people, even the most basic concepts of radiation physics and radiation terminology are foreign and confusing. This is perhaps most obvious when discussing radiation measurement terms. Different units are used depending on what aspect of radiation is being measured. In most countries, radiation experts use the Standard International (SI) units, a uniform system of weights and measures that evolved from the metric system.

The amount of radiation being given off, or emitted, by a radioactive material is measured using the conventional unit curie (Ci), named for the famed scientist Marie Curie, or the SI unit becquerel (Bq). The amount of radioactivity in a source is measured by the number of nuclear decays per second; 1 Ci equals 37 billion decays per second. The more curies present, the greater amount of radioactivity and emitted radiation. This information should be found on labels and/or shipping papers.

More curies = greater amount of radioactivity

The size or weight of a quantity of material does not indicate how much radioactivity is present. A large quantity of material can contain a very small amount of radioactivity, or a very small amount of material can have a lot of radioactivity.

All radioactive materials have a characteristic half-life, defined as the period of time it takes for the substance undergoing decay to decrease by half. Radioactive materials may have a very short half-life (eg, 66 hours for molybdenum-99) to a very long half-life (eg, 24,400 years for plutonium-239).

The human body cannot sense ionizing radiation, but a range of instruments exists that are capable of detecting radiation easily from natural and human-created sources. Some cities have installed radiation monitoring systems that continuously sample the air for radioactive material, which could enhance detection capabilities. First responders and most hazardous materials (HazMat) units are equipped with detectors able to confirm the presence of most types of radiation soon after arrival on the scene (determining the specific type of radioactive material may take longer, because it requires more sophisticated instruments):

- Equipment such as Geiger counters measure the exposure rate of ionizing radiation directly. They contain a gas-filled device that, when a high voltage is applied, creates an electrical pulse if radiation interacts with the wall or gas in the tube. These pulses are converted to a reading on the instrument meter. If the instrument has a speaker, the pulses also give an audible click.
- Dosimeters are small portable instruments (such as a film badge, thermoluminescent, or pocket dosimeter) that are used to measure and record the total accumulated personal dose of ionizing radiation.

3.5 Measurement of Radiation Dose

Since ionizing radiation affects all of us, we need to measure its presence as well as relate the amount of radiation received by the body to its potential health effects. Two terms used to relate the amount of radiation received by the body are exposure and dose. When you are exposed to radiation, your body absorbs a given dose of radiation.

Radiation dose is measured in the SI unit of gray (Gy) for the absorbed dose; and sievert (Sv), for the effective dose. In the United States, the terms for radiation dose, rad and rem are still used by some groups for Gy and Sv, respectively:

- Rad recognizes that different materials that receive the same exposure may not absorb the same amount of energy. A rad measures the amount of radiation energy absorbed by a material (for example, the amount of energy deposited in human tissue by radiation). As mentioned previously, the SI system is now the official system of radiation measurement and uses the "gray" (Gy) for absorbed dose.

- Rem is a unit that relates the absorbed dose in human tissue to the biologic effect of the radiation (that is, the relative risk of various types of radiation exposure). As mentioned previously, the SI system is now the official system of radiation measurement and uses the "sievert" (Sv) for equivalent dose. To relate the absorbed dose of specific types of radiation to their biologic effect, scientists assign a number to each type of ionizing radiation (alpha and beta particles, gamma rays, and x-rays) depending on the ability of the radiation type to transfer energy to the cells of the body. This number is known as the “quality factor” (Q). The "quality factor" must be multiplied by the dose in rad, which then shows the dose in rems. For high energy gamma rays and whole body exposures, 1 rad of exposure results in 1 rem of dose.

When a person is exposed to radiation, scientists can multiply the dose in rad by the quality factor for the type of radiation present and estimate a person's biologic risk in rems.

Risk (in rem) = rad x Q
Risk (in Sv) = Gy x Q

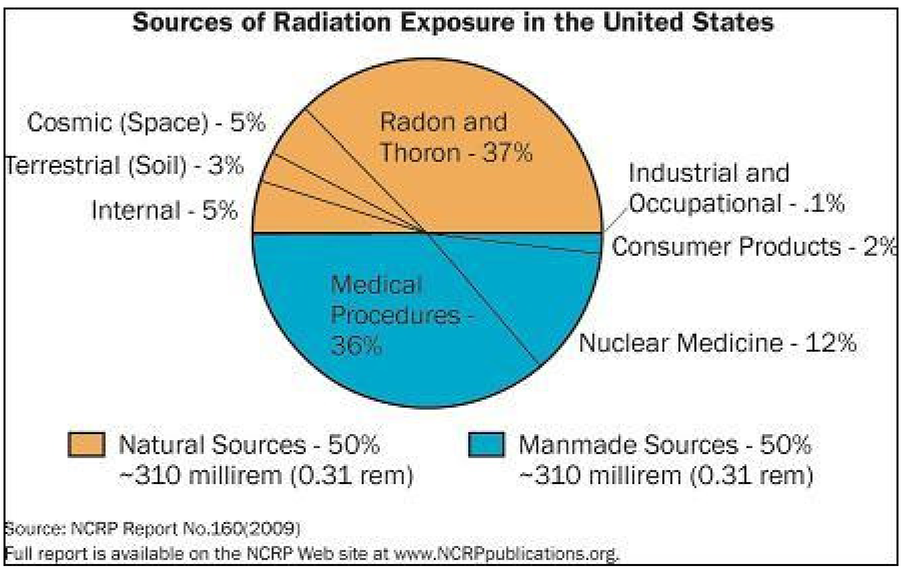
Conversions are as follows:

1 Gy = 100 rad
1 Sv = 100 rem

(Note: for practical purposes, consider the rad and rem to be equal with gamma or x rays. So, 1 rad is equivalent to 1 rem.)

3.6 Sources of Radiation Exposure

Radiation is all around us. It is present in our environment and has been since the origin of this planet. Radiation comes from outer space (cosmic), the ground (terrestrial), and even from within our own bodies. It is present in the air we breathe, the food we eat, the water we drink, and in the construction materials used to build our homes. Certain foods such as bananas and brazil nuts naturally contain higher levels of radiation than other foods. Brick and stone homes have higher natural radiation levels than homes made of other building materials such as wood.



Levels of natural or background radiation can vary greatly from one location to the next. For example, people living in Colorado are exposed to more natural radiation than people living on the east or west coast because Colorado has more cosmic radiation at a higher altitude and more terrestrial radiation from soils enriched in naturally occurring uranium.

As stated previously, in the United States, radiation dose is commonly measured in units called rems or millirems (mrems; 1/1000 of a rem). The average radiation dose per person from all sources is about 620 mrems per year. It is not, however, uncommon for us to receive less or more than that in a given year (largely due to medical procedures we may undergo). International standards allow exposure to as much as 5,000 mrems a year for those who work with and around radioactive material.

The pie chart shows a breakdown of radiation sources that contribute to the average annual U.S. radiation dose of 620 mrem. Although there is a distinction between natural and human-caused radiation, they both affect us in the same way. About half of a person’s total annual average radiation exposure comes from natural sources. The other half is mostly from diagnostic medical procedures.

Take a moment to fill out the "Radiation Dose Chart" developed by the American Nuclear Society (The chart can be printed from http://www.ans.org/pi/resources/dosechart/docs/dosechart.pdf; an interactive version can be found at http://www.new.ans.org/pi/resources/dosechart/).

3.6.1 Natural Radiation

The average annual radiation exposure from natural sources is about 310 millirem (3.1 millisieverts or mSv). Radon and thoron gases account for two-thirds of this exposure, while cosmic, terrestrial, and internal radiation account for the remainder.

Terrestrial Radiation. When the earth was formed billions of years ago, it contained many radioactive materials. Since then, all of the shorter-lived radioactive materials have decayed. Only those radioactive compounds with very long half lives remain, along with the radioactive products formed from the decay of these compounds.

- Soil. Natural radioactive material in rocks and soil accounts for about 3% of the radiation dose a person typically receives in a year from all sources (natural and human-created). The earth's crust contains small amounts of uranium, thorium, and radium, as well as radioactive forms of several elements including potassium. Radiation comes from gamma rays, which are emitted from the rocks, soil, and some building materials (such as bricks and concrete). The presence of these radioactive materials in the ground leads to both external gamma ray exposure and internal exposure from inhalation of radon gas and its decay products.

- Radon. Radon is a gas that moves from the soil, where it is produced, into the air. Radon is a natural part of the earth's atmosphere. The amount of uranium and radium in soil varies greatly with geographic location and soil type. Therefore, the amount of radon gas released to the atmosphere also varies across the United States. Radon gas seeps continuously from bedrock but can, because of its high density, accumulate in poorly ventilated houses.

Cosmic Radiation. Cosmic radiation includes multiple types of radiation, with different energies and wavelengths, from diverse sources in space (such as from our sun, other stars, black holes, and gamma-ray bursts, among others). The high energy particles and waves that comprise cosmic radiation are potentially dangerous, but most of them never make it to earth. Many are deflected by magnetic fields between the earth and the radiation source, they interact with other particles in space, or decay in transit. Cosmic rays and particles that are close to earth interact with the upper atmosphere, which acts as a 'radiaton shield'. If we were in space without the protection of the atmosphere, we would need some other type of shielding from the radiation (spacesuits and protective covering on our spacecrafts).

Sunshine is one of the most familiar forms of cosmic radiation. It provides light, heat, and suntans. Sunshine consists of radiation in a range of wavelengths from long-wave infrared to shorter wavelength ultraviolet. We control its effect with sunglasses, shade, air conditioners, hats, clothes, and sunscreen. There would be no life on earth without sunlight, but we have increasingly recognized that too much of it on our skin is not a good thing. In fact it may be dangerous, so we control our exposure to it.

The exposure of an individual to cosmic rays is greater at higher elevations than at sea level. Cosmic radiation dose increases with altitude, roughly doubling every 6,000 feet. Therefore, a resident of Florida (at sea level) on average receives about 26 mrem, one-half the dose from cosmic radiation as that received by a resident of Denver, Colorado. A passenger in a jetliner traveling at 37,000 feet would receive about 60 times as much dose from cosmic radiation as would a person standing at sea level for the same length of time.

Natural Radioactivity in the Body. Small traces of many naturally occurring radioactive materials are present in the human body. These occur naturally in air, water, and soil; are deposited in the food we eat, water we drink, and air we breathe; and then are incorporated into our body tissues. About 5% of our radiation dose comes from naturally occurring radioactive materials in the body.

3.6.2 Human-Created Radiation Sources

We are also exposed to ionizing radiation from human-created sources; some of these affect the body through direct radiation, while others take the form of radioactive contamination and irradiate the body from within.

Medical Procedures. Diagnostic X-rays, nuclear medicine, and radiation therapy are by far the most significant source of human-created radiation exposure to the general public. Some of the major radioactive materials used are iodine-131, technetium-99m, cobalt-60, iridium-192, and cesium-137. These are rarely released into the environment.

Radiation used in medicine is the largest source of human-created radiation to which people in the United States are exposed. Most of our exposure is from diagnostic x-rays. Physicians use x-rays in help determine the extent of disease or physical injury. On average, doses from a diagnostic x-ray are much lower than natural background radiation.

Radiation therapy can create levels many times higher than natural background radiation but this is usually targeted only to selected tissues. Radiation is used in cancer treatments, where precisely targeted radiation destroys diseased cells without killing nearby healthy cells. Radiopharmaceuticals are used to locate tumors in a patient's body and to treat cancer. One-third of all successful cancer treatments involve radiation.

Consumer Products. In addition to medical applications, extremely small amounts of human-created background radiation are received from consumer products and facilities using radioactive materials including research and teaching institutions, nuclear power plants, and their supporting facilities (such as uranium mills and fuel preparation plants as part of their normal operation). The public also is exposed to radiation from products such as tobacco, building materials, combustible fuels (gas, coal), televisions, luminous watches and dials, airport scanners, smoke detectors, road construction materials, fluorescent lamp starters, and gas lantern mantles.

The tobacco in cigarettes contains lead-210, a naturally occurring radioactive element, which precipitates out of the atmosphere and deposits on the leaves of tobacco. When the tobacco is inhaled, the individual receives a dose from lead-210, as well as polonium-210 (the decay product of lead-210). Lead-210 is deposited on the surfaces of bones and polonium-210 is deposited in the liver, kidney, and spleen.

Table 3-1. Common Radiation Exposures Sources and Doses

Source of Exposure	Dose in Rem	Dose in Sievert (Sv)
Exposure to cosmic rays during a roundtrip airplane flight from New York to Los Angeles	3 mrem	0.03 mSv
One dental x-ray	4–15 mrem	0.04–0.15 mSv
One chest x-ray	10 mrem	0.1 mSv
One mammogram	70 mrem	0.7 mSv
One year of exposure to natural radiation (from soil, cosmic rays, etc.)	300 mrem	3 mSv
Source: CDC, Radiation Emergencies Factsheet; 2003. Available at (www.bt.cdc.gov/radiation/pdf/measurement.pdf)		

3.7 Radiation Exposure Limits

Although some radiation exposure is natural and expected, it is desirable to keep radiation exposure "as low as reasonably achievable" (ALARA). A single high-level radiation exposure delivered to the whole body over a very short period of time may have potentially serious health risks. Very high acute radiation doses can increase the occurrence of certain kinds of disease (eg, cancer) and possibly other negative health outcomes. To protect the public and radiation workers (and environment) from lower-level exposures, current radiation safety practice is to assume that adverse effects, similar to those expected at high dose exposures, are possible with low-level protracted exposure to radiation. Thus, the risks associated with low-level medical, occupational, and environmental radiation exposure are calculated conservatively to be proportional to those observed with high-level exposure.

In the United States, public and occupational regulatory dose limits are set by federal agencies (ie, Environmental Protection Agency, Nuclear Regulatory Commission, and Department of Energy) and state agencies to limit cancer risk. To help enforce these exposure limits, each state has one or more radiation control programs. In 35 states, these programs are in state health departments; in other states, radiation expertise is concentrated elsewhere, often in state environmental agencies.

Above the background level of radiation exposure, the Nuclear Regulatory Commission requires that human-created radiation exposure for individual members of the public be limited to 100 mrem (1 mSv) per year; occupational radiation exposures to adults working with radioactive material is limited to 5,000 mrem (50 mSv) per year. Examples of industries where occupational exposure is a concern include:

- Airline crew (the most exposed population)
- Industrial radiography
- Medical radiology and nuclear medicine
- Uranium mining
- Nuclear power plant and nuclear fuel reprocessing plant workers
- Research laboratories (government, university and private)

4.0 Radiation Threat Scenarios

In the United States, realistic radiation threats include (1) the detonation of a nuclear weapon; (2) a nuclear power plant event that unleashes a radioactive cloud; and (3) the dispersal of radioactive materials by conventional explosives or other means (crash of a transport vehicle). Any of these events could occur unintentionally or as an act of terrorism:

- Possible terrorist events could involve introducing radioactive material into the air or into food and water supplies, using explosives (like dynamite) to scatter radioactive materials (called a "dirty bomb"]), bombing or destroying a nuclear facility, or exploding a small nuclear device. Introducing radioactive material into the food or water supply most likely would cause great concern or fear, it probably would not cause much contamination or increase the danger of adverse health effects. A dirty bomb could cause serious injuries from the explosion. It most likely would not have enough radioactive material in a form that would cause serious radiation sickness among large numbers of people.
- A meltdown or explosion at a nuclear facility could cause a large amount of radioactive material to be released. People at the facility would probably be contaminated with radioactive material and possibly be injured if there was an explosion. People in the surrounding area could be exposed to radiation or contaminated with radioactive materials. The potential danger from an accident at a nuclear power plant is exposure to radiation. This exposure could come from the release of radioactive material from the plant into the environment, usually characterized by a plume (cloud-like formation) of radioactive gases and particles. The major hazards to people in the vicinity of the plume are radiation exposure to the body from the cloud and particles deposited on the ground, inhalation of radioactive materials, and ingestion of radioactive materials. Thirty-one states with commercial nuclear power plants are required to have detailed response plans and drills for designated zones around the power plants.
- An exploded nuclear device would have a significant economic and health impact. Many people would be killed or injured from the blast and might be contaminated by radioactive material. A nuclear device detonated at or near ground level would produce heavy fallout from the dirt and debris sucked up into the mushroom cloud. After a nuclear explosion, radioactive fallout would extend over a large region far from the point of impact, potentially increasing people's risk of developing cancer over time.

Since the atomic bombing of Japan in 1945, with 150,000 casualties and 75,000 fatalities, people have feared nuclear explosives more than any other weapon because of the immediate devastation and trauma, but also because radiation, which cannot be detected by human senses, can cause ongoing health effects, including cancer, years after exposure. In 1987, in Goiania, Brazil, an incident involving a medical source of radioactive cesium-137 contaminated 200 people, 20 significantly, resulting in 4 deaths. In 1986, the Chernobyl reactor accident exposed more than 11,500 people and caused at least 28 deaths due to acute radiation sickness.

In March 2011, an earthquake and tsunami caused damage that led to explosions and partial meltdowns at the Fukushima nuclear reactor complex in Japan. Radiation levels at one of the affected power plants have varied spiking up to 1,000 mSv/h, which is a level that can cause radiation sickness to occur at a later time following a one hour exposure. Significant release in emissions of radioactive particles took place following explosions at three reactors, as technicians tried to pump in seawater to keep the uranium fuel rods cool. Concerns about the possibility of a large-scale radiation leak resulted in a perimeter being set up around the power plant, and notification of people within a specified area to stay indoors. At the time of this writing, the full impact of this radiation emergency was still being studied.

A radiation emergency involves the deliberate or unintentional release of potentially dangerous radioactive materials into the environment to warrant consideration of protective actions. Such incidents can occur anywhere radioactive materials are used, stored, or transported.

In a radiation disaster, affected individuals may experience devastation and disruption of normal societal functions and supportive networks. Survivors may have lost loved ones, lost access to means of transportation, food, water, shelter, clothing, heat, electricity, necessary medications, ability to communicate (both land line and cell phone systems will be "down"), and community support services that have been provided, as well as local medical and hospital access. Residents may lose at least temporarily, the same necessities of daily living and the amenities they most likely consider essential to their lives. For many, the need to relocate can mean the loss of normal social networks, food, spare clothing, medications if they were left behind, perhaps access to financial resources and various other goods and services that we consider necessities of modern life.

Nuclear and radiologic events are often confused with each other, but the two are vastly different in the magnitude and severity of health outcomes. Basically, nuclear events involve very large numbers of deaths and severe injuries, while radiologic events can be expected to have a much smaller or even no impact on morbidity and mortality in an affected population. Either event could be expected to cause significant societal and financial disruption, even change the political landscape. To date, no terrorist events of any large scale have occurred in the United States involving radiologic or nuclear materials or devices. Much of the available information on this topic is derived largely from experience gained in past events involving nuclear facility operations or management of radioactive sources, including (1) nuclear power-generating facilities, (2) military and defense operations, and (3) radiation sources and transport.

4.1 Radiologic Disasters

Radiologic events are defined as those that involve the release of radioactive materials into populated areas (without a nuclear explosion), where panic and environmental contamination are significant hazards, but not necessarily injury. This could involve a simple addition of radioactive materials to food or water, dispersion of radioactive materials into the air, hiding a lethal radiation source (a radiation emission device, or RED) or the infamous “dirty bomb” where radioactive agents are distributed in an area by the explosion of an ordinary (non-nuclear) explosive device (radiation dispersal device, or RDD). While it will be obvious that an explosion has occurred by the blast damage to buildings, it will not be recognized immediately whether the explosion involved the release of radioactive materials.

Radiation sickness may result in radiologic events if there is a high degree of exposure, but in most radiologic scenarios this will be limited. Other less deadly but more likely events could involve a transportation incident, releasing radioactive materials and presenting hazards to limited populations and emergency responders, or inadvertent loss of an industrial source.

Terrorist use of an RDD is considered far more likely than use of a nuclear device. A dirty bomb uses conventional explosives, such as dynamite, to disperse radioactive material (possibly in the form of powder or pellets) across a wide area, although slower and less-dramatic method of dispersal are also possible ways to escape detection. When the bomb explodes, radioactive material is blasted into the area around the explosion. Specks of radioactive material might float in the air or fall on surfaces such as streets, cars, roofs, or people. This could cause people and buildings to be exposed to radioactive material, though the amount of radiation would likely be low. Such radiologic weapons appeal to terrorists because they require very little technical knowledge to build and deploy compared to that of a nuclear device. Also, these radioactive materials, used widely in medicine, agriculture, industry and research, are much more readily available and easy to obtain compared to weapons grade uranium or plutonium. A dirty bomb cannot cause a nuclear explosion.

The greatest danger from a dirty bomb is the blast itself. In most plausible scenarios, the radioactive material released in an RDD would not result in acutely harmful radiation doses, and the primary public health concern from those materials would be increased long term risk of cancer to exposed individuals. Hazards from fire, smoke, shock (physical, electrical, or thermal), shrapnel (from an explosion), hazardous materials, and other chemical or biological agents may also be present. A larger risk to public health would be the fear and anxiety that might ensure after a dirty bomb explosion. In the flight to escape the scene of the blast or in a massive rush to leave the city, people could be trampled, crushed, hit by motor vehicles, and suffer anxiety-induced heart attacks. While people in the immediate area of the explosion could be harmed from the explosion, the main purpose of a dirty bomb is to cause widespread fear and make buildings or land unusable for a long period of time.

4.2 Nuclear Disasters

In stark contrast to a radiologic event, a nuclear event involves a massive explosion, accompanied with a devastating fireball, mass fires, shock waves, gamma radiation pulse, and the production of radioactive fallout. Affected individuals sustain extensive thermal burns, trauma, blindness, and short- and long-term radiation sickness. A nuclear explosion involves the splitting (or fission) of the nuclei of uranium or plutonium. As a result of the explosion, radiation is released, as both electromagnetic waves (eg, ultraviolet, infrared, visible, gamma, and x-ray) and particulate radiation (eg, alpha and beta particles, and neutrons). The intense visible light that occurs is a characteristic feature of a nuclear explosion. There would likely be tens of thousands of deaths and significantly more injuries, even for a relatively small nuclear weapon. Larger devices could increase those numbers ten- to one hundred-fold, which would cripple the response capacities and capabilities of most communities.

A nuclear detonation will be unmistakable from the moment it occurs. The bright flash, the widespread physical destruction, the searing heat, strong winds, and the “mushroom cloud” are unique. During the Cold War, the attack would have been detected as satellites tracked missiles on their 30-minute journey to the United States from Russia, which would have given individuals a chance to get to a fallout shelter. Terrorists are much more likely to deliver the weapon in a less obvious manner, perhaps by a truck or ship, rather than by missile. Hence, there would be little chance for early detection and warning.

Even a small nuclear detonation produces an explosion far surpassing that of conventional explosives. Pound for pound, a nuclear explosion releases about 10 million times more energy than a chemical explosive, such as dynamite or TNT. The heat in a nuclear explosion reaches millions of degrees; the heat produced from a dynamite explosion reaches several thousand degrees. The magnitude of a nuclear explosion is measured in terms of the amount of conventional explosive it would take to create the same energy release. The amount of explosive power from a nuclear detonation or the “yield” is measured relative to TNT, and is usually in the thousands of tons (kilotons, or KT) of TNT. A small nuclear device, for example, would be a 1 KT device; meaning it would produce an explosive yield equal to 1,000 tons of

TNT. For comparison, the size of the bomb used in the Murrah Federal Building in Oklahoma City (1995) was equal to 2 tons of TNT.

Community preparedness to respond to a nuclear detonation could result in life-saving on the order of tens of thousands of lives. After a detonation, public health and safety depend on the ability to quickly make appropriate decisions. Many citizens are not familiar with correct safety measures to protect them from radiation exposure. Empowering people with knowledge can save lives:

- The radiation release from an RDD or nuclear device may start without any advance warning and would likely have a relatively short duration. In a major nuclear power plant accident, there is likely to be several hours or days of warning before the release starts, and the release is likely to be drawn out over many hours. This difference means that most protective action decisions, which may be made in a timely fashion during power plant incidents, must be made much more quickly (and with less information) in an RDD or nuclear incident if they are to be effective.
- Large nuclear facilities have detailed emergency plans developed over years that are periodically exercised including specified protective actions, evacuation routes, and methods to quickly alert the public of the actions to take. This would not necessarily be the case for an RDD or nuclear incident. This level of radiologic emergency planning typically does not exist in most cities and towns without nearby nuclear facilities.
- There is no way of knowing how much warning time there would be before an attack by a terrorist using a nuclear or radiological weapon. A surprise attack remains a possibility. The danger of a massive strategic nuclear attack on the United States involving many weapons receded with the end of the Cold War. However, some terrorists have been supported by nations that have nuclear weapons programs. In general, potential targets include:

    - Strategic missile sites and military bases.
    - Centers of government such as Washington, DC, and state capitals.
    - Important transportation and communication centers.
    - Manufacturing, industrial, technology and financial centers.
    - Petroleum refineries, electrical power plants and chemical plants.
    - Major ports and airfields.

4.2.1 Electromagnetic Pulse (EMP)

A nuclear weapon detonated in or above the earth's atmosphere can create a high-density electrical field, or EMP. The EMP acts like a stroke of lightning but is stronger, faster and briefer. This pulse could damage anything with electronic components in direct line of sight of the explosion of many miles. This could not only knock out almost all ability to obtain information from local authorities on what to do after an attack, but could also severely hamper response efforts. EMP can seriously damage electronic devices connected to power sources or antennas. This includes communication systems, computers, electrical appliances, and motor vehicle and aircraft ignition systems. The damage could range from a minor interruption to actual burnout of components. Most electronic equipment within 1,000 miles of a high-altitude nuclear detonation could be affected. Battery-powered radios with short antennas generally would not be affected. Although an EMP is unlikely to harm most people, it could harm those with pacemakers or other implanted electronic devices.

4.2.2 Radioactive Fallout

Fallout is the raining of radioactive particles out of the cloud of debris tossed up by a nuclear explosion. The radioactive material released into the air by the blast would be carried by the wind to many areas and would eventually "fall out" of the sky onto the ground, buildings, and other objects and surfaces. Fallout generally begins about 20 minutes after the nuclear explosion and continues for many days or even weeks. Most fallout will occur directly beneath the blast site and downwind as the cloud of radioactive debris drifts away. The heaviest, most dangerous, and most noticeable, debris will 'fall out' first closer to the impact zone (called "ground zero"). It may begin arriving minutes after an explosion. The smaller and lighter dust-like particles will typically be arriving hours later, as they drift much farther downwind, often for hundreds of miles. Depending upon the wind and the design of the weapon, the fallout could seriously affect a huge area far away from the blast and would pose the most danger to the survivors.

Gamma radiation is by far the most dangerous radiation given off by fallout. Gamma rays are like X rays, only more penetrating and harmful. Gamma radiation can go through walls, roofs, and protective clothing, and is extremely dangerous. Though very dangerous initially, radioactive fallout from a nuclear explosion loses its intensity quickly because it is giving off so much energy.

5.0 Human Radiation Exposure

When people are asked or demand to be monitored for radioactive contamination, they will primarily want to know the following:

- Was I exposed to radiation?
- Am I radioactive?
- Am I still carrying around radioactive contamination on my body? Skin? Clothes? How do I get it off? Is my condition contagious? Is it curable?
- Did I ingest or inhale radioactive material or otherwise become contaminated internally? If so, how long will the material stay in my body? Should I be medically treated?
- Were my children exposed? What about my unborn child?
- Were my pets exposed? My farm animals?

Human radiation exposure is generally characterized as external contamination, internal contamination, and as total or partial body exposure (as a result of close proximity to a radiation source). Radioactive materials may contaminate homes, workplaces, and other resources, requiring extensive and costly remediation and the potential disruption of lives and livelihoods for long periods of time. Serious psychological problems can result in those who think they are being, or have been, exposed. The immediate health effects of large doses of radiation are well known and can be assessed with the use of simple laboratory tests such as blood cell counts. To decrease injury and death from a radiation disaster or terrorist attack, citizens should have a basic understanding of radiation exposure and its consequences.

5.1 Contamination with Radioactive Material

Contamination occurs when radioactive material, which may be in the form of a gas, liquid, or solid, gets onto the skin, or into the lungs, gut, or open wounds. Buildings, motor vehicles, and other inanimate objects can become coated with radioactive particles. A person contaminated with radioactive materials will be exposed (irradiated) until the source of radiation is removed.

Radioactive materials released into the environment can cause air, water, surfaces, soil, plants, buildings, people, or animals to become contaminated. A contaminated person has radioactive materials on or inside their body. The environment is contaminated if radioactive material is spread about or is unconfined. Contaminated pets can present a health risk to pet owners especially children who pet them.

It is important to remember that radiation does not spread or get "on" or "in" people; rather, it is radioactive contamination that can be spread. A person is not contaminated with alpha or beta particles per se, but with a radioactive material that emits these particles. A good way to think of this is to imagine a sealed container of radioactive baby powder (assume this one emits gamma rays). One can hold the container and be exposed to the gamma rays penetrating through the walls of the container without getting the baby powder on his/her hands. Should a leak develop around the lid allowing some of the material to escape, the person may have the powder on his/her hands, thus resulting in contamination of the individual.

Radioactive contamination is not immediately life threatening. There is no standard threshold of radioactivity (external or internal) above which a person is considered contaminated and below which a person is considered uncontaminated.

5.1.1 External Contamination

External contamination occurs when radioactive material, in the form of dust, powder, or liquid, comes into contact with a person's skin, hair, or clothing. In other words, the contact is external to a person's body. People who are externally contaminated can become internally contaminated if radioactive material gets into their bodies. People who are externally contaminated with radioactive material can contaminate other people or surfaces that they touch. For example, people who have radioactive dust on their clothing may spread the radioactive dust when they sit in chairs or hug other people. External radioactive contamination can be assessed with readily available radiation survey meters, such as Geiger counters.

5.1.2 Internal Contamination

Internal contamination occurs when people swallow or breathe in radioactive materials, or when radioactive materials enter the body through an open wound or are absorbed through the skin. Some types of radioactive materials stay in the body and are deposited in different body organs. Other types are eliminated from the body in blood, sweat, urine, and feces. People who are internally contaminated can expose people near them to radiation from the radioactive material inside their bodies. The body fluids (blood, sweat, urine) of an internally contaminated person can contain radioactive materials. Coming in contact with these body fluids can result in contamination and/or exposure.

Internal contamination by strong gamma emitters can be detected by whole body counters, radiation meters, or laboratory testing (bioassays). Internal contamination by most alpha and beta emitters requires a urine bioassay. Persons who have inhaled or ingested radioactive material require medical attention. Currently, there are no reliable antidotes to treat patients once radiation is inhaled or ingested but symptoms can be treated effectively. Oral and intravenous treatments are available that can help remove certain radioactive materials from the body.

5.2 Total or Partial Body Radiation Exposure

A person is irradiated when they are “exposed” to ionizing radiation in much the same way a person is “exposed” to light when someone shines a flashlight on them. In the case of irradiation there is no material transferred. This means that an irradiated person has no radioactive material on them and poses no radiological hazard to others. When a person is exposed to radiation, the energy penetrates the body. For example, when a person has an x-ray, he or she is exposed to radiation.

Total or partial body exposure occurs when an external source irradiates the body either superficially to the skin or deeply into internal organs, with the depth depending on the type and energy of the radiation involved. People who have had total or partial body exposure but no contamination are not radioactive and therefore cannot expose their caregivers to radiation. This occurs when radiation penetrates the body from an external source, such as with a chest x-ray. The radiation may either be absorbed by the body or pass through the body.

<u>Acute radiation exposure</u> occurs during a short period of time. There are routine brief exposures, and the boundary at which it becomes significant is difficult to identify. Extreme examples include:

- Instantaneous flashes from nuclear explosions.
- Exposures of minutes to hours during handling of highly radioactive sources.
- Laboratory and manufacturing accidents.
- Intentional and accidental high medical doses.

Exposure to ionizing radiation over an extended period of time is called <u>chronic exposure</u>. The term chronic (Greek cronos = time) refers to the duration, not the magnitude or seriousness. Natural background radiation results in chronic exposure, which varies among individuals according to geographic, occupational, and genetic factors. The effects of acute radiaton exposure are more easily studied than those of chronic exposure.

5.3 Prenatal Radiation Exposure

Pregnant women should consult with their physicians if they have any concern about radiation exposure to their fetus. The exposure of a fetus to radiation is referred to as prenatal radiation exposure. This can occur when the mother's abdomen is exposed to radiation from outside her body. Also, a pregnant woman who accidentally swallows or breathes in radioactive materials may absorb that substance into her bloodstream. From the mother's blood, radioactive materials may pass through the umbilical cord to the baby or concentrate in areas of the mother's body near the womb (such as the urinary bladder) and expose the fetus to radiation.

6.0 Possible Health Consequences of Radiation Exposure

Ionizing radiation is electromagnetic energy or energetic particles emitted from an atomic source. It causes injury by depositing energy in tissue, which can damage DNA and other cell structures and processes. The extent of injury and risk of long-term health effects are proportional to the dose received and the rate of delivery. Radiation exposure can potentially result in short-term and long-term effects in every organ system in the body. The effect of radiation exposure will depend on numerous variables, including the:

- Type of exposure (total or partial body exposure; internal or external contamination);

- Route of exposure (eg, skin contact or breathing in/ingesting contaminated material);
- Type of tissue exposed (tissue that is sensitive to radiation vs. tissue that is insensitive);
- Type of radiation (eg, alpha, beta, gamma);
- Depth of penetration of radiation in the body (low vs. high energy);
- Total absorbed dose; and
- Period over which the dose is absorbed (dose rate).

The type of radiation and the dose rates that are involved in an RDD would typically be very different from those seen in the detonation of a nuclear bomb, which is why the consequences of these events may differ substantially. For any levels or amounts of exposure, even miniscule, people will want to know what immediate health effects they may confront, as well as long-term risks of exposure. Local emergency response officials will have a communication strategy to address people's understandable fears and anxiety. An important message that needs to be conveyed is that most radiation exposures will not result in measurable health effects.

Goiania, Brazil, Radiation Emergency
In 1985, a private radiotherapy institute in Goiania, Brazil, moved to a new location, leaving behind an unsecured cesium-137 radiotherapy unit that had previously been used in cancer therapy. The source remained in the vacant building for about 2 years. It was discovered by two persons who entered the premises and, not knowing what the unit was but thinking it might have some scrap value, removed the radioactive cesium-137 source assembly. They took the assembly home, and when they attempted to dismantle it, the source capsule ruptured, exposing them to radiation. This resulted in localized burns to their bodies; one of the men later had to have an arm amputated. The radioactive source was in the form of cesium chloride salt, which is highly soluble and readily dispersible. As a consequence, they contaminated themselves, hundreds of others, and the surrounding city and environment. Thus began one of the most serious radiation incidents ever to have occurred.   A local physicist was the first to assess the scale of the incident and took actions on his own initiative to evacuate two areas. After appropriate authorities were informed, several other sites of significant contamination were quickly identified and secured. Many individuals incurred external and internal exposure. In total, some 112,000 persons were monitored, of whom 249 were contaminated either internally or externally. Four deaths were attributed to this exposure. Some exposed persons suffered very high internal and external contamination owing to the way they handled the cesium chloride powder, such as eating with contaminated hands and via contamination of buildings, furnishings, and utensils.

6.1 Biologic Effects of Radiation Exposure

Radiation exerts its toxic effect on biologic systems through ionization, which disrupts cells and molecules directly and also produces highly reactive free radicals, which attack nearby cells. Free radicals are atoms or groups of atoms with an odd (unpaired) number of electrons. Once formed these highly reactive radicals can start a chain reaction. Their chief danger comes from the damage they can do when they react with important cellular components.

The biologic effects of radiation are usually considered in terms of their effects on living cells. The body can repair many types of radiation damage if the dose is received slowly. The same dose, received more rapidly, can overwhelm cell repair mechanisms, leading to cell death and possible cancer. Biologic effects of radiation on living cells may result in a variety of outcomes, including:

- Cells experience DNA damage and are able to detect and repair the damage.
- Cells experience DNA damage and are unable to repair the damage. These cells may go through the process of programmed cell death. If the cells are not critical for survival, the clinical effects may be negligible. However, acute doses that kill large numbers of cells or kill cells essential for organ function will cause clinical symptoms. Rapidly dividing cells, such as those of the gastrointestinal tract lining and the bone marrow, are most sensitive.
- Cells experience a nonlethal DNA mutation that is passed on to subsequent cell divisions. This mutation may contribute to the formation of a cancer.
- Cells experience "irreparable DNA damage." Low level ionizing radiation may induce irreparable DNA damage leading to pre-mature aging and cancer.

The net effect is that biologic molecules suffer damage that may exceed the body's repair capacity, and may also cause mutations in cells currently undergoing replication. The associations between ionizing radiation exposure and the development of health problems (such as cancer) are based mostly on populations exposed to relatively high levels of ionizing radiation, such as Japanese atomic bomb survivors, and recipients of selected diagnostic or therapeutic medical procedures.

6.2 Clinical Effects of Radiation Exposure

Health effects after a radiation exposure will depend greatly on the circumstances surrounding the release. After detonation of a nuclear weapon or RDD, there may be thermal or blast injury in addition to radiation exposure. In contrast, a nuclear power plant disaster can produce a radioactive cloud with no associated blast. Depending on the dose, dose rate, and route of exposure, radiation can cause acute radiation syndrome (ARS), skin injury, eye damage (due to exposure to infrared energy), and increased long term risk for cancer, cataract formation, infertility and fetal abnormalities and fetal death. Casualty management is dependent on the type and degree of radiation exposure and the presence of other injuries.

Radiation can affect the body in a number of ways, and the adverse health effects of exposure may not be apparent for many years. These adverse health effects can range from mild effects, such as skin reddening, to serious effects such as cancer and death, depending on the amount of radiation absorbed by the body (the dose), the type of radiation, the route of exposure, and the length of time a person was exposed. Exposure to very large doses of radiation may cause death within a few days or months. Exposure to lower doses may lead to an increased risk of developing cancer or other health problems later in life. Children exposed to radiation may be at more risk than adults; unborn children may be at even greater risk because the human embryo or fetus is extremely sensitive to radiation.

Radiation exposure, like sun exposure, is cumulative to some degree. Although radiation damage is also to some extent cumulative, damage from radiation can be repaired. Thus chronic exposure to radiation is less damaging than acute exposure to the same level (eg, 100 rem in an hour may cause illness; the same amount spread over a year will likely have no health effect). High radiation doses tend to kill cells, while low doses tend to damage or alter the genetic code (DNA) of irradiated cells.

The immediate danger from the detonation of a nuclear device would be the fireball, producing extremely high temperatures, and emitting radiation. Injuries would include massive numbers of burns, fractures, lacerations, loss of limbs, temporary flash blindness, and possible permanent retinal scarring. Adverse health effects from radiation exposure, ranging from mild (skin reddening) to severe (radiation sickness, cancer) depending on the type of radiation and the route and duration of exposure. People who survive the immediate effect of a nuclear detonation are likely to suffer from combined injury. That means in addition to radiation exposure, they have sustained burns and physical trauma.

In a nuclear event, there will be a spectrum of injury types and severity, including those from blast, radiation, and heat (or fire). These may occur alone or in combination.

Exposure to above-normal levels of radiation can lead to fatigue, nausea, and vomiting, and changes in the levels of various blood cell components. It also can increase the risk of developing cancer later in life. Exposure to very large doses of radiation can kill so many cells that tissues and organs are damaged immediately. This in turn may cause a rapid organ system response often called acute radiation syndrome. The higher the radiation dose, the sooner the effects of radiation illness will appear, and the higher the probability of death. This syndrome was observed in many atomic bomb survivors in 1945 and emergency workers responding to the 1986 Chernobyl nuclear power plant accident. Approximately 134 plant workers and firefighters battling the fire at the Chernobyl power plant received high radiation doses – 80,000 to 1,600,000 mrem (800 to 16,000 mSv) – and suffered from acute radiation sickness. Of these, 28 died within the first three months from their radiation injuries. Two more patients died during the first days as a result of combined injuries from the fire and radiation.

People who are exposed to radiation fall into one of three general categories:

- Individuals who may be expected to make a full recovery from their radiation exposure with little or no medical intervention.
- Individuals who are unlikely to survive regardless of the level of medical care provided.
- Individuals whose survival will depend on the careful administration of supportive care. The ability to deliver supportive care will depend on the number of casualties and available resources.

Treatment considerations for individuals suffering from radiation exposure include:

- Medications to control infections (antibiotics, antivirals, and antifungal medications)
- Medications to control vomiting and diarrhea
- Replacement of fluids and electrolytes
- Pain management
- Blood and blood product transfusions
- Stem cell transplantation
- Drugs to minimize internal radiation contamination
- Combined injury management (ie, treatment of burns and other injuries)

Acute Radiation Syndrome (ARS)

Exposure to a very large doses of radiation, known as acute radiation sickness (ARS) or "radiation sickness" can result in death within days to months. People are susceptible to ARS, only if the radiation dose is high, penetrating (able to reach internal organs), and is received by most or all of the body in a short time, usually minutes. The first symptoms of ARS are nausea, vomiting, and diarrhea. These symptoms may start within minutes or days of exposure and may last for minutes to several days; the symptoms also may come and go.

An exposed person may then feel healthy for a short time, until suffering loss of appetite, fatigue, fever, nausea, vomiting, and diarrhea and possible experience seizures an coma. Such serious illness may last from a few hours to several months an the recovery process can take weeks or years.

Most people who do not recover from ARS die within weeks or months of exposure, generally from the destruction of bone marrow, resulting in infections and internal bleeding. Surviving ARS is inversely related to the amount of radiation exposure (the less exposure, the greater the chance of survival).

Specific health outcomes after radiation exposure are typically divided into short-term and long-term. Short-term effects appear within days to weeks after exposure; long-term effects appear months to years later. Short-term effects are dependent on the degree of radiation exposure and the tissue irradiated. Immediate clinical effects of large doses of radiation are well known and can be assessed with the use of simple laboratory tests such as blood cell counts.

Following a nuclear detonation, adults who receive a dose of 300 rem (3 Sv) are likely to die within 30 to 180 days if they receive no medical treatment. Even with good medical treatment, 15% to 30% of those exposed at this radiation level will likely die. A dose of 600 rem (6 Sv) will kill 95% to 100% of those exposed, without medical treatment. The number of deaths could be reduced by up to 50% with good medical treatment. Little can be done to save the lives of those exposed to 1,000 rem or more (> 10 Sv).

Genetic effects and the development of cancer are the primary long-term health concerns attributed to radiation exposure. The likelihood of cancer occurring after radiation exposure is about five times greater than a genetic effect (eg, increased still births, congenital abnormalities, infant mortality, childhood mortality, and decreased birth weight). Genetic effects are the result of a mutation produced in the reproductive cells of an exposed individual that are passed on to their offspring. These effects may appear in the exposed person's direct offspring, or may appear several generations later, depending on whether the altered genes are dominant or recessive. Although radiation-induced genetic effects have been observed in laboratory animals (given very high doses of radiation), no evidence of genetic effects has been observed among the children born to atomic bomb survivors during World War II.

The period of time between radiation exposure and the detection of cancer is known as the latent period. Those cancers that may develop as a result of radiation exposure are indistinguishable from those that occur naturally or as a result of exposure to other carcinogens (chemical and physical hazards and lifestyle factors, such as smoking, alcohol consumption, and diet, significantly contribute to many of these same diseases.) Although radiation may cause cancer at high doses and high dose rates, public health data regarding lower levels of exposure, below about 1,000 mrem (10 mSv), are harder to interpret. People living in areas having high levels of background radiation – above 1,000 mrem (10 mSv) per year – such as Denver, Colorado, have shown no adverse biologic effects. Even so, the radiation protection community conservatively assumes that any amount of radiation may pose some risk for causing cancer and hereditary effect, and that the risk is higher for higher radiation exposures.

6.3 Risk to Pregnant Women and Fetuses

One of the most misunderstood issues regarding radiation exposure is the relative risk to pregnant women and prenatally exposed infants. It is important to distinguish between high dose x-ray exposures in medical practice and environmental exposure to radioactive fallout from nuclear weapons or other radiologic sources. In medical practice, it is documented that for X-rays, children exposed prenatally or soon after birth are more sensitive to radiation exposure than older children and young adults. In unfortunate exposures to x-rays in utero in the past, fetuses were found to suffer, depending upon the stage in gestation, an increased risk of physical and psychological defects in childhood. While it has been shown that intense X-ray exposure has produced birth defects in humans, there has been a limited amount of defects reported in Japanese atomic bomb survivors.

For environmental radiation exposures following the Chernobyl disaster, there was no significant increase in birth defects in babies born to women from the highly contaminated areas. This is an interesting finding, as there was more than 100 times as much radioactivity released at Chernobyl into the air as occurred with Hiroshima and Nagasaki combined. The uterine and abdominal walls of the mother do provide some shielding against radiation exposure; the dose inside the uterus is roughly two-thirds of the dose at the mother's skin. In general, the fetus either survives the radiation intact, or fails to implant in the uterus and dies.

The risk to the fetus is highest for radiation exposure after eight weeks of gestation. After 25 weeks, these risks are minimal. High radiation doses will increase the probability of miscarriage and neonatal death. In conjunction with the very low incidence of birth defects after the atomic bomb detonations in Japan, the fear of significant numbers of birth defects from environmental exposures to radioactive materials deposited from airborne dispersion is not justified. In both the immediate aftermath and during the long-term medical response to nuclear weapon and radiologic exposures, therefore, termination of pregnancy secondary to the anticipation of radiation induced birth defects is not scientifically justified. Counseling of pregnant mothers from contaminated areas needs to take into account that 30,000 women decided to terminate their pregnancies at Chernobyl for the sole reason of fear of birth defects in their babies, an outcome that did not come to pass.

There is, however, an elevated risk of childhood leukemia and solid tissue cancers in childhood that does increase with increasing dose. The fetus is probably as sensitive to radiation-induced cancer as young children. There is a theoretical possibility, based on animal studies and chromosomal studies in humans, that subsequent generations will be at increased risk for birth defects and cancers; however, there are no scientific data, in Japan or elsewhere, that have actually demonstrated this. It should be stated that if either or both parents are irradiated prior to conception, there is no evidence to demonstrate increased birth defects or cancer in their children.

7.0 Preparation and Planning for Radiation Disasters

In any disaster, you may have to evacuate at a moment's notice and take essentials with you. You probably won't have the opportunity to shop or search for the supplies you'll need. Your household will cope best by preparing for a radiation disaster before it strikes. Develop your own family emergency plan so that every family member knows what to do.

States and local governments have developed strategies to protect local and regional populations after a radiation release. These include the establishment of threshold radiation concentrations that would require evacuation and educational campaigns for the public. Local planning focuses on the creation of disaster management protocols, education of first responders and healthcare professionals, and acquisition of appropriate equipment and supplies.

- Your community should have a plan in case of a radiation emergency. Check with community leaders to learn more about the plan and possible evacuation routes.
- Check with your child's school, the nursing home of a family member, and your employer to see what their plans are for dealing with a radiation emergency.
- If you live within 10 miles of a nuclear power plant, learn the emergency warning systems for the power plant. If you do not know how the power plant has planned to alert your community, contact the utility company that operates the power plant. The utility company is required by law to have plans in place for contacting people in the community during an emergency. The utility company also must inform the community each year of its evacuation plans and routes.

All citizens need to be educated and informed about radiation disasters. To prepare for such an emergency, citizens should be advised to do the following:

7.1 Have a Plan

- Learn the warning signals and all sources of warning used in your community. Make sure you know what the signals are, what they mean, how they will be used, and what you should do if you hear them.
- Plan how your household would stay in contact if you were separated. Identify two meeting places: the first should be near your home in case of fire, perhaps a tree or a telephone pole; the second should be away from your neighborhood in case you cannot return home.
- Pick a friend or relative who lives out of the area for household members to call to say they are okay.
- Post emergency telephone numbers by telephones. Teach children how and when to call 911.
- Make sure everyone in your household knows how and when to shut off water, gas, and electricity at the main switches. Consult with your local utilities if you have questions.
- Take a basic first aid class. Local American Red Cross chapters and hospitals can provide information.
- Consider ways to help neighbors who may need special assistance, such as the elderly or the disabled.
- Make arrangements for pets. Pets are not allowed in public shelters. Service animals for those who depend on them are allowed.
- Acquire other emergency preparedness booklets that you may need.

7.2 Identify Sheltering Options in Advance

- Find out from officials if any public buildings in your community have been designated as radiation fallout shelters. If none have been designated, make your own list of potential shelters near your home, workplace, and school. These places would include basements or the windowless center area of middle floors in high-rise buildings, as well as subways and tunnels. You may need to call your local emergency management office.

- Look for yellow and black fallout shelter signs on public buildings (note: with the end of the Cold War, many of the signs have been removed from the buildings previously designated). Give household members clear instructions about where fallout shelters are located and what actions to take in case of attack.
- If you live in an apartment building or high-rise, talk to the manager about the safest place in the building for sheltering and about providing for building occupants until it is safe to go out.

7.3 Prepare a Disaster Supplies Kit

It is important to have a personal disaster supplies kit adequate to support you and your family. This kit should include a few essential items: a dust mask with an N95-rated particulate filter, which will protect against radioactive dust and fallout, as well as biologic agents. These are inexpensive, readily available, and easy to store at home, at work, and in the car. Another is a battery-operated radio, which could be a critical tool for receiving information about when it is safe to vacate shelters and other instructions from government officials.

An emergency could happen at any time, so it is best to stock supplies in advance. Assemble and maintain food, water, medications, fuel, and personal items adequate for up to 2 weeks; the more the better. Put together a kit that would be appropriate for any disaster. Don't forget other members of your family. If you have an infant, store extra formula and diapers. If you have pets keep an adequate supply of pet food. Although it is unlikely that food supplies would be cut off for as long as two weeks, consider storing additional water, food, clothing, and bedding other supplies to expand your supply kit to cover this time span. Stock up on supplies, just as you would in case of severe weather conditions or other emergencies. Check the supplies every 6 months. Replace any expired medications, food, or batteries. Also, replace the water in your shelter every 6 months to keep it fresh. A list of suggested supplies is included in the Appendix to this document.

It is also important to consider storing a personal supply of water and food at work; you will not be able to rely on water fountains or coolers. Women who wear high-heels should be sure to have comfortable flat shoes at their workplace in case an evacuation requires walking long distances. Keep a smaller disaster supply kit in the trunk of you car in case you become stranded or are not able to return home.

7.4 Plan for a Medical Emergency

Wearing an emergency ID bracelet or necklace or carrying an emergency information card could save your life if you are unable to speak after a serious injury or illness. This medical identification is particularly important for people with chronic conditions such as diabetes, epilepsy, glaucoma, or hemophilia, or those who may have a serious allergic reaction to certain medications (such as penicillin) or to insect stings. Talk with your doctor about the need to wear an emergency ID bracelet or necklace or carry an emergency information card, and discuss what information should be included to inform others about your health conditions and needs.

These bracelets, necklaces, and cards include such information as the individual's name, address, blood type, doctors, medications, person(s) you want contacted in an emergency with their address and phone number, and any serious conditions or allergies. These items are available through several manufacturers. Ask your doctor, hospital emergency department, or local medical association where you can order them.

In Case of Emergency (ICE)

A new practice that has gained widespread recognition is to make an entry in your cell phone directory for ICE (In Case of Emergency) with the contact information for the person who should be called if you are ill or injured and cannot tell someone whom to call. Emergency medical and hospital personnel are now being taught to look for this information in cell phone directories. In addition, if there is a "note filed" capability in your cell phone, you can put key medical information in the ICE listing such as allergies, medications, and medical conditions.

7.5 Know How to Get Help

When faced with a disaster or other medical emergency, immediately dial 911 or the local emergency medical dispatch number on any available phone and do not hang up until help arrives. This action will provide you, in most circumstances, with a person trained to assist, as you await the arrival of appropriate emergency medical personnel and vehicles at your location.

It is important to have quick access to the names and telephone numbers of doctors and other healthcare personnel who provide regular care to you and your family members. A list should be maintained with contact information (complete names, addresses, and phone numbers) of family members, legal guardians, and others who have responsibility for making healthcare decisions in an emergency. Take time to fill out the "Emergency Notification Form" provided in Appendix B of this guide.

Reporting Emergencies

Any suspicious or confirmed emergency situation should be reported immediately by calling 911 or your local emergency medical dispatch number. If you are sick or injured, first try to contact your physician to determine if emergency medical care is warranted. If he or she is not available, call 911 or other local emergency medical dispatch number.

If you believe that someone has been exposed deliberately to a biologic, chemical, or radioactive agent, or if you believe a terrorist threat will occur or is occurring, contact your local FBI office, police or other law enforcement agency, or health department.

Upon arrival at the scene, first responders will follow steps outlined in their standard operating procedures or local emergency response plan to notify authorities and request additional assistance.

7.6 Have an Evacuation Plan

- Learn about your community's evacuation plans. Such plans may include evacuation routes, relocation sites, how the public will be notified and transportation options for people who do not own cars and those who have special needs. Ask your local emergency management office about community evacuation plans.
- Learn evacuation routes. If you do not have your own transportation, make plans in advance of an emergency with people who can give you a ride. Check with local officials to see what plans are in place to evacuate people who cannot or do not drive.

- Keep fuel in your vehicle if an evacuation seems likely. Gas stations may be closed or damaged during a disaster. They will be unable to pump gas during power outages. If you do not own a motor vehicle, make transportation arrangements with friends or your local government. Talk with family members about the possibility of evacuation. Plan where you would go if you had to leave the community. Determine how you would get there.
- Plan a place to meet your household in case you are separated from one another in a disaster. Ask a friend outside your town to be the "checkpoint" so that everyone in the household can call that person to say they are safe. Find out where children will be sent if schools are evacuated.

7.7 Plan for Special Health and Medical Needs

If you have a disability or special need, you may have to take additional steps to protect yourself and your household in an emergency. If you know of friends or neighbors with special needs, help them with these extra precautions. Examples include:

- Hearing impaired individuals may need to make special arrangements to receive a warning.
- Mobility impaired individuals may need assistance in getting to a shelter.
- Households with a single working parent may need help from others both in planning for disasters and during an emergency.
- Non-English speaking people may need assistance planning for and responding to emergencies.
- Community and cultural groups may be able to help keep these populations informed.
- People without vehicles may need to make arrangements for transportation.
- People with special dietary needs should have an adequate emergency food supply.

Find out about special assistance that may be available in your community. Register with the office of emergency services or fire department for assistance, so needed help can be provided quickly in an emergency. Create a network of neighbors, relatives, friends and co-workers to aid you in an emergency. Discuss your needs and make sure they know how to operate necessary medical equipment. Discuss your needs with your employer. If you are mobility impaired and live or work in a high-rise building, have an escape route. If you live in an apartment building, ask the management to mark accessible exits clearly and to make arrangements to help you evacuate the building. Keep extra wheelchair batteries, oxygen, catheters, medication, food for companion animals, or other items you might need. Also, keep a list of the type and serial numbers of medical devices you need. Those who are not disabled should learn who in their neighborhood or building is disabled so that they may assist them during emergencies. If you are a caregiver for a person with special needs, make sure you have a plan to communicate if an emergency occurs.

7.8 Plan for Pets

If you are concerned about your pets, you should make plans before an emergency for taking them with you. Most emergency shelters will not accept pets (only service animals, such as dogs used by visually impaired people). You should contact friends or relatives in other areas to see if you may bring your pets to their homes in the case of an emergency.

7.9 Get Trained, Get Involved, Be Ready

The need for trained citizens is vital in the first minutes, hours, and even days after an event, when survivors may have no alternative to treating and caring for themselves, their families, coworkers, and neighbors. At times, citizens may be required to act independently for many hours after a disaster event until outside help arrives. To improve personal and community preparedness, all citizens should seek disaster training to make sure they can:

- Recognize potential life-threatening situations and act appropriately, while protecting personal health and safety;
- Know how to contact and work with local emergency medical and public health systems;
- Make decisions with limited resources and limited information;
- Access reliable disaster health information and resources; and
- Know about medical, social, and mental health resources that are available

Learn about opportunities that are available to become more involved in local disaster preparedness and response efforts. Sign up for a first aid training course. In many communities, disaster education and training is available through chapters of the American Red Cross, through Citizen Corps Councils, Medical Reserve Corps units, and Community Emergency Response Teams. The Citizen Corps was created within the Department of Homeland Security to help coordinate volunteer activities to make communities safer, stronger, and better prepared to respond to any emergency situation (such as, crime threats, terrorism, and disasters).

The Citizen Corps

The five Citizen Corps programs are:

- The **Community Emergency Response Team (CERT) program** (www.citizencorps.gov/cert/index.shtm), administered by FEMA, prepares people to help themselves, their families, and their neighbors in the event of a disaster in their community. Through local CERTs, citizens can learn about disaster preparedness and receive training in basic disaster response skills such as fire safety, light search and rescue, and disaster medical operations. With this training, volunteers can provide immediate assistance to victims before first responders arrive on scene. CERT volunteers also participate in community preparedness outreach activities.

- The **Fire Corps** (www.firecorps.org) promotes the use of citizen volunteers to support and augment the capacity of resource-constrained fire and emergency service departments at all levels: volunteer, career, and combination (career/volunteer). Fire Corps is funded through the Department of Homeland Security and is managed and implemented through a partnership between the National Volunteer Fire Council and the International Association of Fire Chiefs.

- The **Medical Reserve Corps** (MRC) Program (www.medicalreservecorps.gov) reports directly to the U.S. Surgeon General. The MRC aims to improve the health and safety of communities across the country by organizing and utilizing public health, medical, and other volunteers who donate their time and expertise to prepare for and respond to emergencies. Volunteer MRC units accomplish this mission by supplementing existing emergency and public health resources during local emergencies.

- **USAonWatch** (www.usaonwatch.org) is the face of the National Neighborhood

Watch Program. The program is managed nationally by the National Sheriffs' Association in partnership with U.S. Department of Justice. USAonWatch empowers citizens to become active in homeland security efforts through community participation. This is accomplished through information, training, technical support, and resources to local law enforcement agencies and citizens.

- The **Volunteers in Police Service** (VIPS) Program (www.policevolunteers.org) serves as a gateway to information for law enforcement agencies and citizens interested in law enforcement volunteer programs. The program's ultimate goal is to enhance the capacity of state and local law enforcement agencies by incorporating the time and skills that volunteers can contribute to a community law enforcement agency. The International Association of Chiefs of Police manages the VIPS Program in partnership with the U.S. Department of Justice.

8.0 When Disaster Strikes

In a disaster, individuals and communities may have to deal with an increased demand for medical resources, especially in rural areas and when local emergency medical services and hospitals are overwhelmed. The first minutes or hours are the most critical for seriously injured persons. During this time, doctors and other skilled emergency responders will probably not be available at the disaster scene. Even when they arrive, emergency responders and relief workers cannot reach everyone right away. In such situations, citizens can help give immediate assistance at a time when rapid intervention may be essential for survival.

Until help arrives, citizens will be the “first responders” to care for injured victims. In such situations, citizens should be able to:

- Recognize and protect themselves from potential dangers and hazards;
- Know how and when to call for help;
- Be willing and able to help without interfering with organized response efforts; and
- Know how to provide critical life support.

In a disaster, early detection, rapid reporting, and immediate action are important to reduce casualties. Any suspicious or confirmed emergency situation should be reported immediately by calling 911 or other local emergency medical dispatch number. Local and state governments are responsible for protecting citizens and helping them to respond and recover.

When a disaster situation is beyond the capabilities of the state and local government, the state governor can ask for federal assistance. Following a request for federal support by a governor and the subsequent declaration of an emergency by the president of the United States, the federal government provides local and state governments with personnel, technical experts, equipment, and other resources.

A radiation disaster would involve multiple federal, state, and local response agencies. Emergency workers and local officials are trained to respond to disaster situations and will provide specific actions to help keep people safe. State and local authorities, working closely with federal agencies, would develop the appropriate response actions; for example, initiation of the emergency broadcast system, providing information on protective measures, and the creation of local shelters for displaced people. Protective actions will be implemented to reduce or eliminate exposure of the public to radiation and other hazards:

- The principal protective action decisions for consideration in the early and intermediate phases of a radiation emergency are whether to shelter-in-place, evacuate, or relocate affected or potentially exposed populations.
- Secondary actions include administration of medications, decontamination (including decontamination of persons evacuated from the affected area), restricting entry and exit routes, and providing access to food and water.

In some situations, only one protective action needs to be implemented, while in others, numerous protective actions should be implemented. Many factors should be considered when deciding whether or not to order a protective action based on the projected radiation dose to a population.

If a radiation emergency occurs, people can take actions to protect themselves, their loved ones, and their pets. Your first priority is to survive. Then, given the dangers that radioactive dust and fallout present to the human body, you must decontaminate yourself. Recognize that you may not be able to help anyone else; most individuals are not qualified to provide the kinds of medical treatment that would be needed. Do not attempt to contact family or friends until you have ensured your own safety.

In a nuclear detonation, there will be no significant federal response at the scene for days. Individuals will need to survive on their own. Basic services, such as electricity, gas, water, sewage treatment and telephones, may be cut off for days, even a week or longer. Local officials and relief workers will be on the scene after a disaster, but they cannot reach everyone immediately.

8.1 Limiting Radiation Exposure

A person contaminated with radioactive material will receive radiation exposure until the source of radiation (the radioactive material) is removed. A common sense and most prudent approach is to limit the spread of the material. This is usually done by proper utilization of protective clothing, controlling entry and exit to/from a contaminated area, minimizing the amount of material dispersed into the air, and proper radiation monitoring. There are other methods to control the spread of contamination (eg, avoiding actions that may resuspend the material, covering or removing unnecessary items from the area), but typically, contamination control is a process that, although important, needn't be overly complicated.

Respiratory protection can be achieved by using particulate filter masks (N95) or other expedient measures, such as covering the nose and mouth with clothing or towels. Protective clothing provides no protection from gamma radiation, although it can provide significant protection from beta radiation. It is recommended that exposed skin be covered but again only if it does not impede evacuation or taking shelter. In this context, any clothing that covers exposed skin and the head is considered protective clothing. Thus, most fully dressed individuals would only need a hat or hood. Protective clothing has the additional advantage of facilitating decontamination by providing a layer that can be quickly removed to dispose of any fallout material that may have accumulated on a person during evacuation or prior to sheltering.

Radioactive fallout is like dust or sand. If the material falls on your skin, it may cause burns; if it falls in the food or water supplies or becomes resuspended into the air you breathe, it might be harmful if ingested or inhaled. Therefore, if you were outside in the fallout, before you enter a building you should remove your outer clothing and leave it outside. Do not shake clothing inside the house or shelter or you may contaminate those areas as well. You should wash all areas of your skin and hair that was exposed to the fallout. Food and water supplies should be protected by some covering, such as in a shelter or stored in plastic containers or bags. If these outer containers become contaminated, they should be washed first and the items inside carefully removed, taking great care not to transfer contamination from the outer container to the items inside. Use gloves or other hand coverings when handling potentially contaminated items.

Decisions with the biggest lifesaving effect will likely be those made in the first minutes or hours. Wait for more information and instruction before evacuating. Sheltered individuals should stay put for at least 24 hours unless authorities provide different instructions. Effective communication is critical. Stay tuned to Emergency Alert System radio stations, as well as local commercial media. Local officials will be providing specific information and instructions. Listen for the specific warnings. Not all incidents result in the release of radiation. The incident could be contained and pose no danger to the public.

<u>Distance</u>. During a radiation disaster, people should seek to limit exposure by increasing their distance from the impacted area; increasing the distance decreases the intensity of immediate health effects from the blast, heat, and emitted radiations. The farther a person is from a source of radiation, the lower the radiation dose. This could be evacuation or remaining indoors to minimize exposure. An underground area such as a home or office building basement offers more protection than the first floor of a building. A floor near the middle of a high-rise may be better, depending on what is nearby at that level on which significant fallout particles would collect. Flat roofs collect fallout particles so the top floor is not a good choice, nor is a floor adjacent to a neighboring flat roof.

No evacuation should be attempted until basic information is available regarding the presence of radiation and radiation dose rates.

<u>Shielding</u>. Placing a radioactive source behind a massive object provides a barrier that can reduce radiation exposure. Depending on the type of radioactivity, effective shielding could be as thin as a piece of paper (for alpha radiation) or as thick as a lead-lined wall (for gamma radiation). The more shielding between an individual and the radiation source, the less the radiation intensity.

<u>Time</u>**.** The shorter the time in a radiation field, the less the radiation exposure you will receive. Most radioactive materials lose their strength fairly quickly.

Key Radiation Self-Protection Measures
Since radiation cannot be seen, smelled, felt, or tasted, people may not know whether radioactive materials were involved. The key to safety in any public health emergency is to pay attention to local radio and TV broadcasts for information. Until instructions from city or state officials are issued through such broadcasts, take the following precautions to limit radiation exposure:

- Remain calm.
- Avoid contamination with radioactive materials. Assume that all food, equipment, people, animals, and environments that may have come in contact with a radioactive material are contaminated.
- Wear a dosimeter, such as a film or TLD badge, if issued.
- Move away from the source of the radioactive agent release to as far away as possible. Get out of the immediate impact area quickly. Go inside the nearest safe building or to an area to which you are directed by law enforcement or health officials. *[See Sections 8.2, 8.3, and 8.4]*
    - If you are outside, find shelter in the nearest building. Wear protective clothing and cover mouth and nose with a wet cloth to block airway exposure; also consider covering exposed skin. Wear protective clothing that, if contaminated, can be removed.
    - If already inside, remain there; keep the windows closed, and minimize the opening of doors to the outside. Turn off fans, air conditioners, and forced-air heating units that bring in fresh air from the outside. Use these only to circulate indoor air.
- Some injuries (eg, eye injuries, blast injuries-particularly from flying debris and glass) may be prevented or reduced in severity if individuals who perceive an intense and unexpected flash of light seek immediate cover. In a nuclear detonation, the speed of light, perceived as a flash, will travel faster that the blast pressure wave allowing a few seconds for some people to take limited protective measures.
- Once you are safely away from the contaminated area, wait for emergency responders or listen for directions. Tune into television or radio for further instructions from public health and emergency management officials.
- Avoid unnecessary hand-to-face contact to minimize potential spread of contamination (eg, avoid smoking, chewing gum). Try to avoid spreading contamination to parts of the body that may not be contaminated, such as areas that were clothed. Keep cuts and abrasions covered when handling contaminated items to avoid getting radioactive material in them.
- Attempt to remove external radiation contamination. *[See Personal Decontamination, Section 8.6]*
- Check with your doctor or other local health authorities to determine if monitoring for external and/or internal radiation contamination is recommended. If internal contamination may have occurred, you may be able to take medication to reduce the radioactive material in your body.
- If you must go outside for lifesaving activities, cover your nose and mouth and avoid stirring up or breathing in dust as much as possible. Do not eat any fruit or vegetables grown in an area affected directly by radiation fallout (radioactive particles that may settle on the ground).

Remember that any protection, however temporary, is better than none at all. The more shielding, distance, and time you can take advantage of, the better.

8.2 Seeking "Adequate Shelter" in a Radiation Disaster

There are 2 principal actions that may be taken to protect the public from radiation and radioactive fallout: taking shelter and evacuation. A good definition of shelter-in-place is to stay where you are, IF you are inside a stable building that is not at risk of collapse, flooding, or fire. If you are outside or in a building threatened by collapse or fire, get inside the nearest stable building. The best initial action immediately following a radiation emergency is to take shelter in the nearest and most protective building or structure and listen for instructions from authorities.

Shelters such as houses with basements, large multi-story structures, and parking garages or tunnels can generally reduce radiation doses from fallout by tenfold or more. Single story wood frame houses without basements and vehicles provide only minimal shelter and should not be considered adequate shelter in a radiation fallout zone.

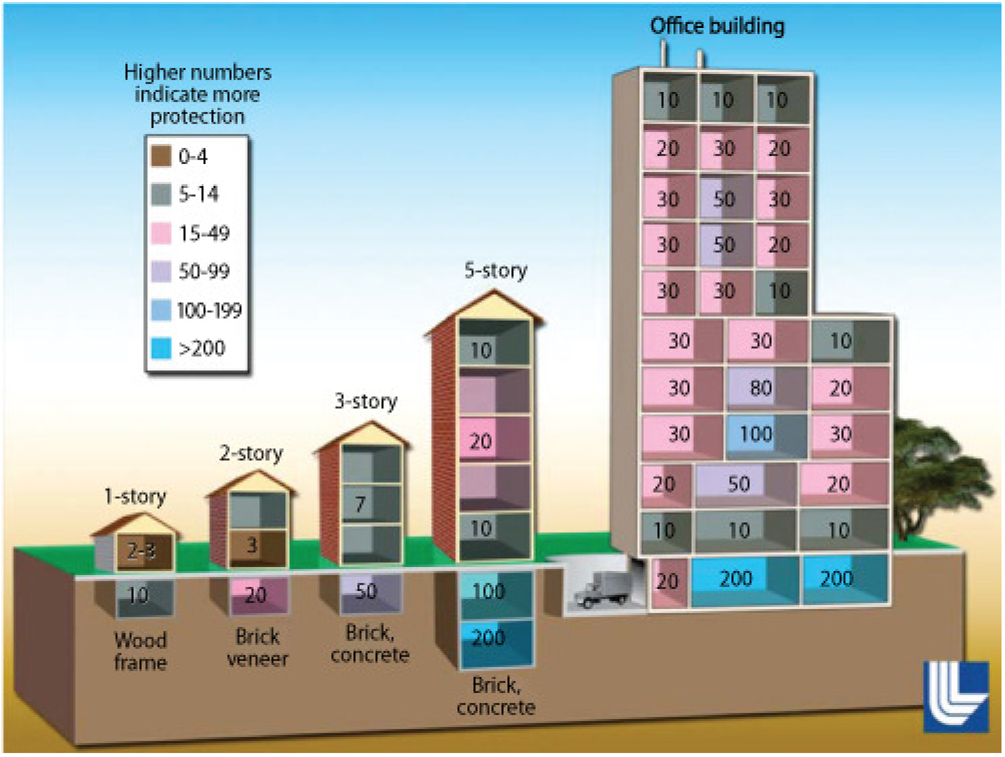
The primary safety and health hazard in a radiation emergency is inhalation of radioactive particulate matter generated from an explosion or other type of release (eg, aerosol). A simple and effective way to prevent this is to take shelter in a structure that blocks the infiltration of particulates. This action is attractive because it is simple, quick, and effective. The onset of the exposure hazard in a radiologic attack initiated with a bomb is expected to be immediate, and the exposure is greatest in the first few hours, while dust and other particulate matter is still airborne. Adequate shelters provide a shield from fallout's penetrating radiation. If a person is outside the area where buildings have collapsed, there will be a few minutes in which to take refuge in an adequate shelter. Buildings can serve as shelters, providing a shield that reduces exposure to penetrating radiation. However, not all buildings offer adequate shelter—hence the move away from the general advice to "shelter in place."

The adequacy of a shelter depends on the degree to which it protects from penetrating radiation, which is expressed as "protection factor (PF)." The higher the PF, the more protection a shelter confers, and the lower a shielded person's exposure, as compared with an unsheltered person at the same location.

- A PF <10 is considered inadequate protection from penetrating radiation. Inadequate shelters include cars and light single-story residential or small commercial structures without basements.
- A PF ≥10 is considered adequate shelter, which may be found in, for instance, the periphery or top floor of office buildings, shallow basements, and multi-story brick or concrete buildings.

Good protection (PF = 100) may be found in the cores of large office buildings and the basements of multi-story buildings. If it can be done in 30 minutes or less, people should move from inadequate to adequate or good shelter (see Figure 10-1). As mentioned previously, because radioactive particles decay quickly (ie, lose their strength), the passage of time is also an important factor in radiation exposure.

Figure 10-1. Sample Protection Factors (PFs) for a Variety of Building Types and Locations



Source: Buddemeier BR, Dillon MB. Key Response Planning Factors for the Aftermath of Nuclear Terrorism. Livermore, CA: Lawrence Livermore National Laboratory LLNL-TR-410067, August 2009. http://www.remm.nlm.gov/IND_ResponsePlanning_LLNL-TR-410067.pdf. Accessed June 28, 2010.

Because it could be difficult to know where you are in relation to the detonation and because the yield of the weapon is not known, the more shelter the better. In all cases, once inside the shelter, shut off all air circulation systems and close off doorways and windows. The room should not be sealed completely, because enough air will be needed to breathe for at least 48 hours. Individuals should remain in the shelter and await guidance from officials about when it is safe to leave, which could take 24 to 48 hours. Individuals should attempt to gain access to their emergency supply kit for use while in the shelter, but it is better to reach a good shelter in time without the kit. The ideal shelter would be prestocked with supplies to support occupants for at least two to three days.

8.3 Sheltering In Place

In a radiation disaster, people who live near the disaster scene may be asked to stay home and take shelter rather than try to evacuate. Because many radioactive materials decay rapidly and dissipate, staying at home for a short time may protect you from radiation exposure. The walls of your home may block much of the harmful radiation.

> In a nuclear event, everyone should seek shelter regardless of proximity to ground zero or orientation to the actual path of fallout. Because of the unique nature of radiation dangers associated with a nuclear explosion, the most lives will be saved in the first 60 minutes through sheltering in place.

Taking a few simple precautions can help you reduce your exposure to radiation:

- The safest place in your home during an emergency involving radioactive materials is a centrally located room or basement. Any underground area is the best place to shelter from fallout. This area should have as few windows as possible. The further your shelter is from windows, the safer you will be.
- Before entering the shelter, turn off fans, air conditioners, and forced-air heating units that bring air in from the outside. Close and lock all windows and doors, and close fireplace dampers. In large buildings, building superintendents should set all ventilation systems to 100 percent recirculation so that no outside air is drawn into the building. If this is not possible, ventilation systems should be turned off.
- When you move to your shelter, use duct tape and plastic sheeting to seal any doors, windows, or vents for a short period of time in case a radiation plume is passing over (listen to your radio for instructions). Stuff a towel tightly under each door and tape around the sides and top of the door. Cover each window and vent in the room with a single piece of plastic sheeting, taping all around the edges of the sheeting to provide a continuous seal. Within a few hours, you should remove the plastic and duct tape and ventilate the room. If there are any cracks or holes in the room, such as those around pipes entering a bathroom, fill them with modeling clay or other similar material.
- Remain in the shelter room and keep your radio tuned to an emergency response network at all times for updates on the situation. Radio news broadcasts will provide information about when you may leave your shelter and whether you need to take other emergency measures. Follow all instructions given by emergency authorities. If authorities warn of the possibility of an outdoor explosion, close all drapes, curtains, and shades in the room. Stay away from windows to prevent injury from breaking glass.
- If you have pets, prepare a place for them to relieve themselves in the shelter. Pets should not go outside during a radiation emergency because they may track radioactive materials from fallout into the shelter. Preparing a place for pets will keep the radioactive materials from getting inside the shelter.
- Assemble an emergency toilet, if necessary.
  - Use a garbage container, pail or bucket with a snug-fitting cover. If the container is small, use a larger container with a cover for waste disposal. Line both containers with plastic bags.
  - After each use, pour or sprinkle a small amount of regular household disinfectant, such as chlorine bleach, into the container to reduce odors and germs.
- When authorities advise people in your area to leave their shelters, open all doors and windows and turn on air conditioning and ventilation systems.

8.4 Evacuation Considerations

Disaster situations can be intense, stressful, and confusing. Should an evacuation be necessary, local authorities will do their best to keep the public informed. Often, a disaster can strike with little or no warning, providing local authorities scant time to issue an evacuation order. It is possible that you may not hear an evacuation order due to communications or power failure or not having access to a battery-powered radio. In the absence of evacuation instructions from local authorities, you should evacuate only if you feel you and your household are threatened or endangered.

In a radiation disaster, local authorities will give immediate guidance on whether to evacuate immediately or whether to shelter in place for a defined time. It should be noted that after a nuclear detonation, fallout within 24 to 48 hours is the most dangerous. Traveling within the projected fallout pattern before 48 hours has passed could cause significant injury, internal contamination, and death. If evacuation orders are given, multiple routes should be provided (assuming risk of further radiation exposure is similar for each). Dedicated routes for inbound emergency vehicles and outbound emergency vehicles also will be designated.

In a nuclear detonation, evacuation should be done in areas not affected by dangerous levels of fallout. Uninjured survivors may need to evacuate or relocate to avoid additional radiation dose; particularly if the available shelter provides more of a health risk than the temporary increase in radiation exposure that might be involved while evacuating to a less irradiated location. Unfortunately, unless trusted, accurate, and prompt directions are given by the media, the public won't know which options are best. In an actual incident, there may even be "evacuation" into areas of greater radiation risk.

Motor vehicles offer virtually no protection against radiation from fallout. Accordingly, if the evacuation route to the nearest medical treatment facility is across a plume of fallout, an alternate facility may need to be chosen. The fallout zone could extend 10 to 20 miles or more from ground zero, depending upon yield. This requires controlled evacuation so that people spend the least amount of time in moving from a dangerously contaminated area to a safer one.

If told to evacuate, do not return home until local officials deem it safe. Each situation can be different, so local officials will give special instructions to follow that are particular to the situation. Act quickly and follow the instructions of local officials and emergency coordinators. If you have time, turn off the air conditioner, heating system, or ventilation system to the house. Close and lock all windows and doors if you have time. Gather water, food, clothing, emergency supplies, and important personal records (eg, insurance and financial records). Evacuate to a designated place to be monitored and checked for contamination, if told to do so.

If you are told to evacuate, keep vehicle windows and vents closed; use re-circulating air. Follow recommended evacuation routes. Do not take shortcuts. They may be blocked. Let others know what you are doing and where you are going.

8.5 Use of Potassium Iodide (KI) During a Radiation Disaster

Potassium iodide (KI) helps protect the thyroid gland from radioactive iodine (iodine-131). Once it enters the body, iodine-131 accumulates in the thyroid gland, where it can be a source of substantial doses of radiation. A person who is internally contaminated with radioactive iodine may experience thyroid disease later in life.

KI is a blocking agent that comes in the form of a tablet. It is sold without a prescription (under brand names such as IOSAT and ThyroSafe). There is a finite period of time immediately before and after inhaling or ingesting radioactive iodine during which KI can be effective. The uptake of radioactive iodine should be blocked by taking oral KI within 4 hours of exposure. If taken in time, KI blocks the uptake of radioactive iodine by saturating the thyroid gland with non-radioactive iodine, thus decreasing the amount of harmful radioactive iodine that can be absorbed. It is important to note that KI can only be effective when radioactive iodine is a contaminant of concern. It offers no protection for other radioactive materials (a "dirty bomb" most likely will not contain radioactive iodine).

The use of KI is most important for babies, children, and pregnant or nursing women; and least important for people over 40 years of age. Children are particularly susceptible to the potential for thyroid cancer following exposure to radioactive iodine. Some people may be allergic to KI.

There are alternatives to KI, but they should be discussed with the individual's personal physician.

Public health officials in states with operating nuclear power plants and communities surrounding nuclear power plants are already familiar with KI and its potential use in an off-site release of radioactive iodine from the power plants. No one can predict how far a radiation plume might spread. Stocking KI pills may make sense for those living near a nuclear plant. If you live in a state or a community without nuclear power plants, you may consult your friends or relatives in other states about how their communities have incorporated KI in their emergency plans. Consideration is generally given to include KI as a protective measure for the general public living within 10 miles of a nuclear power plant to supplement sheltering and evacuation in the event of a severe accident. It is up to each state to make a final decision on the use of KI as a supplemental protective measure. Nuclear plant emergency plans already provide for distribution of KI to emergency workers and to certain institutionalized populations, such as hospital patients within emergency planning zones.

Remember, the best measure of protection is to avoid radioactive material in the first place. The use of KI is usually regarded as a potential supplementary measure of protection, not a primary one, even in cases of radioactive iodine contamination. The use of KI is a reasonable, prudent, and inexpensive supplement to evacuation and sheltering, which protects the whole body from radiation exposure.

8.6 Personal Decontamination

Like dirt, most radioactive contamination washes off with soap and water. This process is called decontamination. People should act as if they were going home in clothes covered with mud and did not want to track it into their homes. If radioactive material is on your clothes, removing it will not only reduce the external contamination but decrease the risk of internal contamination. Removing clothing can eliminate up to 90% of radioactive contamination. By taking this simple step, you will reduce the time that you are exposed and also your risk of injury from the radiation.

Radioactive material trapped on a person's clothing, hair, or skin can pose an exposure hazard that remains even after direct contact from suspended particulate matter has been eliminated. Therefore, anyone who has been exposed to radioactive material should undergo decontamination once safely sheltered from the source of radioactive material. Decontamination should initially focus on removing any respirable dust, which would involve removing outer clothing and securing it in a bag or other container. While the hazard is primarily respiratory, contact of radioactive material with skin and eyes should be minimized by rinsing exposed skin, removing contact lenses, and showering as soon as possible. The danger posed by contaminated clothing may persist for a long time, so contaminated clothing should be treated or disposed of in accordance with official guidance.

Decontamination of persons is generally not considered a lifesaving issue. Simply brushing off outer garments will be sufficient to protect oneself and others until more thorough decontamination can be accomplished. Most peopled should be able to self decontaminate, but provisions will be needed for those who cannot, such a people using wheel chairs or people with other disabilities.

Decontaminate as soon as possible once you are protected from the radiation hazard. People who do not have serious injuries should perform the following:

- Remove clothing and place it in a sealed plastic bag (to avoid contaminating the living space, consider undressing at the doorway or in the garage)
- Wash/shower thoroughly with warm (not scalding hot) water and soap to remove contamination, allowing the water to run away from the face
- Use the mechanical action of flushing or friction using a cloth, sponge, or soft brush
- Begin with the least aggressive techniques and mildest cleaning agents (eg, soap and water)
- When showering, begin with the head, bending forward to direct wash water away from the body
- Keep material out of the eyes, nose, mouth, and wounds;
- Gently blow nose and clean out eyes and ears.
- Change into uncontaminated clothing.
- Wash out the tub or shower.
- Avoid mechanical, chemical, or other damage to the skin.

Decontamination can provide protection for anyone who has been contaminated with radioactive material that has adhered to the body.

8.7 Screening for External Radiation Contamination

In a radiation emergency, large numbers of people may need to be screened for external contamination using equipment such as hand-held Geiger Mueller detectors or portal monitors (radiation detection devices normally used for the screening of transport vehicles). Screening for external contamination is performed to assess the amount of radioactive materials on the skin and clothing. These materials can irradiate the body when beta and gamma-emitting compounds are present. If the radioactive material remains on skin or clothing, it could be released to the air and inhaled, or be incidentally ingested, resulting in internal contamination. External contamination on individuals can also be spread, resulting in cross-contamination; that is, spreading radioactive materials to other places where they should not be. Cross contamination is a public health concern, although it is secondary to immediate concerns for people's health and safety.

8.8 Screening for Internal Radiation Contamination

As mentioned previously, internal contamination is when radioactive material enters the body through, for example, ingestion or inhalation. Some types of radioactive materials stay in the body and are deposited in different body organs. If the radiation dose is significant, the person may have an increased risk of developing cancer. Over time, the radioactive materials are eliminated from the body in blood, sweat, urine, and feces. This could take days, months, or years, depending on the type of radioactive material, and its physical and biological half-lives. In case of extremely high doses, internal contamination with radioactive material could be lethal. However, this is extremely rare. RDD incidents are likely to result in small (most likely inconsequential) amounts of internal contamination.

Having accurate information about the levels of internal contamination is important in deciding whether medical treatment is warranted. Having internal contamination does not necessarily mean the person is going to experience health problems. Every day, thousands of people in the United States receive diagnostic tests that involve administering traces of short-lived internal radioactive materials on an outpatient basis, and they are released to go home after their procedures.

The methods and equipment needed for assessing internal contamination are more advanced than the equipment required to conduct external monitoring. Collectively, internal contamination monitoring procedures are referred to as "bioassays," and in general these bioassays require off-site analysis (by a clinically certified commercial laboratory or hospital). People should be advised that it may be some time before results are available. Laboratory results will provide more definitive information, especially in the case of alpha-emitting materials.

For gamma-emitting materials, external monitoring can provide some indication of the extent of internal contamination. Furthermore, the physical location of the individuals during the incident or the extent of external contamination on their bodies prior to washing can be additional indicators of the likelihood and magnitude of internal contamination.

When a person is internally contaminated, depending on the type of radioactive material he/she is contaminated with, certain medications can be administered to speed up the rate at which the radioactive material is eliminated from the body. Note that internal decontamination is a medical procedure that should only be performed at the order and under the guidance of a licensed physician. The amount of internal radioactive contamination is only one of many parameters a physician would evaluate in assessing the need for treatment. A person's age and general health and organ function (such as kidney, liver, lung) are among the information physicians would need to make their best medical judgment.

8.9 The Strategic National Stockpile

A national pharmaceutical supply, called the Strategic National Stockpile (SNS), is managed by the Centers for Disease Control and Prevention (CDC) to provide large supplies of many of the pharmaceutical agents that we would expect to need in a mass casualty disaster such as a nuclear event (see www.cdc.gov/phpr/stockpile.htm). Additionally, the federal government and the US military have the capability to mobilize and deliver medical facilities that can care for several thousands of patients. These supplies and facilities, however, will take at least 24 hours and in some cases up to five days to deliver and set up. With the reality that supplies held in the SNS will not reach the scene for at least 24 hours, states should have plans for stockpiling of various medications and medial supplies that will be necessary in such an event. This would include stockpiles of generic categories of routine medications used by patients on a daily basis, in addition to medications that would be specifically needed to treat victims of a nuclear event. Some of these would include but not be limited to pain medications, wound care and burn medications, and antibiotics. The SNS maintains several drugs that can be used to treat people who are internally contaminated with certain radioactive materials or who are externally exposed to radiation. The decision to use such drugs is a medical one that must be made by appropriate medical authorities.

8.10 Altered Care Environment in a Nuclear Disaster

Nuclear events are likely to cause a very significant change in medical care services due to the enormous number of injuries. Initially, when resources are scarce, assets will be committed to maximizing lives saved and relieving pain and suffering. Resource scarcities will vary dramatically by distance from ground zero and time after the incident. Early on, many casualties who would be provided definitive care under circumstances with sufficient resources, may be “triaged” into an “expectant” (expected to die) category. To the extent possible, these individuals will receive compassionate care and treatment of symptoms (such as pain management).

In a serious disaster, medical care may be different than what is typically encountered in non-disaster healthcare settings. The standard of medical care that is expected by most citizens may very well have to be altered to treat large numbers of casualties and provide the greatest good for the largest number of people. Healthcare needs may overwhelm immediately available resources, and therefore, not all injured and ill people may receive full medical care. Access to medical resources may be limited further by communication, transportation, and other constraints. To save the most lives possible, quick decisions must be made for the efficient use of immediately available resources.

In day-to-day emergencies, medical care is delivered in physician offices, clinics, and emergency departments, with the objective to do the greatest good for each individual patient. In a large-scale disaster, involving multiple casualties, this objective changes to doing the greatest good for the greatest number of possible survivors. Responders may only be able to provide care for immediately life-threatening problems for the highest priority casualties; other casualties will still be evaluated but may only receive supportive care. As resources become available, medical care will be distributed according to the severity of need, balanced with the likelihood of survival.

This altered care environment also refers to the concept of treating large numbers of casualties outside of traditional hospital settings due to limitations in medical resources and staff. In a nuclear disaster, local and regional healthcare facilities may be damaged or otherwise overwhelmed by the large number of casualties. Additionally, the ability to move large numbers of people to distant locations for care will be severely limited. Efforts will be devoted to providing medical care for many less critically injured or ill people in settings outside of traditional hospitals. These settings, called alternate care facilities, would be staffed by health professionals with community volunteer support. Alternate care facilities would be established in schools and other locations that have adequate sanitary and other support capabilities. Volunteers from the community would be recruited in advance, and receive basic training in the operation of these facilities.

9.0 Public Health Response Actions

If a radiation emergency occurs in your community, the chief local elected official (the mayor or city or county manager) is responsible for coordinating the overall local response and resources. State and local public health agencies will have many responsibilities, including:

- Protecting the public’s health and safety.
- Monitoring worker health and safety.
- Ensuring provision of health and medical services.
- Ensuring safe shelters for the population.
- Ensuring the safety of food and water supplies.
- Coordinating sampling and laboratory analysis of biological and environmental samples.
- Conducting field investigations.
- Monitoring people who may have been contaminated with radioactive materials or exposed to radiation (population monitoring).

- Conducting or assisting in decontamination.
- Developing criteria for entry and operations within the disaster site.
- Recommending injury and disease prevention and control measures.
- Recommending management protocols for affected populations or individuals.
- Communicating necessary information to medical providers.
- Communicating situation assessments and required safety measures to the public.
- Assisting law enforcement agencies with any criminal investigation.

Local health agencies may call on state health officials, who in turn may request assistance from the federal government. Public health authorities and emergency planners will identify and prioritize special populations in the community that have special needs after a radiation incident. These include:

- Children
- Elderly people
- Pregnant women
- People with chronic medical and mental health problems
- Disabled persons
- Workers (eg, emergency responders, transient or migrant workers, commuters)
- Homeless people
- Institutionalized individuals who may or may not be able to evacuate or relocate.
    - Hospital patients.
    - Residents of nursing homes or other institutions.
    - Prison inmates, guards, and workers required to maintain, operate, or secure critical and essential infrastructure.

9.1 Crisis and Emergency Risk Communication

During any disaster, getting accurate information to people quickly is a key component to saving lives. Crisis and emergency risk communication provides information for individuals and communities to support the best possible decisions to protect their health and safety. During emergencies, the public may receive information from a variety of sources. Communication of clear, concise, and credible information can reassure the public that the situation is being addressed competently. Effective public information must reach broad audiences to publicize both immediate and anticipated health hazards, appropriate health and safety precautions, the need for evacuation, and alternative travel routes. The media can play an important role in this regard by keeping the public informed. During a disaster, the aims of risk communication are to:

- Help people more accurately understand their own risks
- Provide background information and reassurance to affected individuals and populations by answering these questions:
    - How could this happen?
    - Has this happened before?
    - How can I prevent this from happening again?
    - Will I be all right in the long term—will I recover?
- Gain understanding and support for response and recovery plans
- Listen to stakeholder and audience feedback and correct misinformation
- Explain emergency recommendations
- Empower risk/benefit decision making

In a radiation disaster, it is critical that clear and fully informative advice be presented to the public. Experience during the Three Mile Island incident yielded valuable information of what not to do. A nuclear or radiologic 'expert' cannot expect either members of the general public or members of the emergency response community or elected officials to simply agree to 'trust me'. Explicit explanations must be made in as simple terms as possible, avoiding complex technical arguments, for any recommendations regarding public activity in a radiologic incident. Guidelines for the general public should be couched in terms that provide instruction regarding means to protect the individual or family in a contaminated area, in a non-contaminated area, and should be concise. A simple 'shelter-in-place' instruction should be issued with explanation on means to reduce the dose to the affected population.

Limits on public radiation exposure may need to be modified during an incident. The limit for public exposure is nominally 1 mSv/year (100 mrem/year). In many, if not most, radiologic and nuclear incidents, this will simply not be possible. A radiation expert should be consulted on the exposure levels that the public is likely to receive in the specific incident. To minimize panic, instructions to shelter in place or wear respiratory protection should be issued as soon as possible and with calm confidence that the recommendation will assist the public in protecting themselves. Public health officials will provide as much guidance as possible to empower the public with tools to control their environment.

Most people have some resources they can use to control inhalation of contaminated materials. Even a simple fabric covering the mouth and nose can reduce inspired contamination. It will be important to remind the public that radioactive material is 'radioactive dirt', and keeping it out of one's body is important. Every possible alert communication mechanism will need to be employed after a nuclear event, especially because of the likely loss of the power grid and the ensuing chaos affecting communication networks. This will include traditional media outlets such as television, radio, and Internet news, as well as email, text messaging, and social media outlets. Unfortunately, it is likely that many of these systems will not be available in the actual nuclear disaster area.

9.2 Population Monitoring

The term "population monitoring" refers to the immediate screening of exposed populations after a radiation event for health effects. Substantial effort will be expended on determining dose to the public from a radiation exposure. Within the first hours and days after an event, people will be monitored using special equipment designed to detect radiation. Public health officials will use this information to find out whether people are contaminated internally or externally with radioactive materials. Public health officials also will estimate the amount of radiation to which people were exposed (known as the dose) through a process called dose reconstruction. In addition, emergency response workers will be monitored to see if they are suffering any health effects.

In a radiologic or nuclear disaster, it is necessary to perform long-term monitoring of exposed individuals and populations. There is a risk of cancer and delayed health effects (cataracts), which can occur even at doses insufficient to cause moderate or severe symptoms in the first days or weeks post exposure. People who have undergone external or internal radiation exposure screening should have a permanent record of the screening results and the survey instrument recording.

State and local agencies will consider establishing a registry system as early as possible following a radiation emergency. This would be used to contact people who require short-term medical follow-up as well as long-term monitoring. Documentation of exposed people will provide significant challenges but will be required for long-term health reasons and to address legal issues. Responsibility for obtaining and maintaining these records lies with state, tribal, or local public health departments.

The US Department of Health and Human Services (HHS) is responsible for assisting state, local, and tribal governments in monitoring people for external and internal radiation contamination. The HHS also is responsible for supporting state, local, and tribal governments in decontaminating people who are internally contaminated by providing guidance on giving medications that can speed up the removal of radioactive material from the body. The HHS will help local and state health departments create the registry (or list) of people who might have been exposed to radiation from the incident. As part of the work on the registry, the HHS will help the local and state health departments determine how much radiation people were exposed to and follow people for as long as necessary to see whether they develop health effects from radiation exposure or from the stress of being involved in the disaster.

10.0 Recovering from a Radiation Disaster

Recovering from a radiation disaster, or any disaster for that matter, is usually a gradual process. Safety is a primary issue, as are mental and physical well-being. Disaster relief focuses on meeting people's immediate survival needs. Disaster relief workers provide shelter, food, and medical and mental health services. Disaster relief organizations, such as the American Red Cross and the Salvation Army, help individuals and families return to normal daily activities. In addition, relief workers may feed emergency workers, handle questions from family members outside the disaster area, provide blood and blood products to disaster victims, and help those affected by disaster to get other available resources.

Response personnel will provide for the safety, security, and survival (eg, food and shelter) of affected individuals and populations; ensure people are informed of disaster response and recovery efforts; facilitate communications with family, friends, and community, and reduce ongoing hazards. It is important that a trusted spokesperson is identified who is credible and who can provide accurate and timely assessments of what is and what is not known. To reduce population fear and anxiety, rumors should be anticipated and debunked as quickly as possible. If assistance is available, knowing how to access it makes the process faster and less stressful. The following steps can help you get your home, community, and life back to normal:

<u>Protect your health and safety</u>. Find out how to care for your safety after a disaster. Also consider health and safety issues affecting family members and friends. Be aware of new safety issues created by the incident. Watch for damaged roads, contaminated buildings, contaminated water, gas leaks, broken glass, damaged electrical wiring, and slippery floors. Inform local authorities about health and safety issues, including chemical spills, downed power lines, washed out roads, smoldering insulation, and dead animals.

<u>Maintain personal health</u>. Be aware of exhaustion. Don't try to do too much at once. Set priorities and pace yourself. Get enough rest. Drink plenty of clean water. Eat well. Wear sturdy work boots and gloves. Wash your hands thoroughly with soap and clean water often when working in debris. Seek medical treatment for any unusual symptoms, such as nausea, that may be related to radiation exposure.

Assist the sick and injured. Do not attempt to move seriously injured persons unless they are in immediate danger of death or further injury. If you must move an unconscious person, first stabilize the neck and back, then call for help immediately. If the person is not breathing, carefully position the victim for artificial respiration, clear the airway, and commence mouth-to-mouth resuscitation. Maintain body temperature with blankets. Be sure the person does not become overheated. Never try to feed liquids to an unconscious person.

Relocate outside the contaminated zone, only if instructed to do so by public officials. Although contamination levels from a radiologic weapon are likely to be quite low, long-term exposure may be high enough in some areas that authorities will ask individuals to leave their homes or businesses for some period of time. Relocation does not need to be done quickly because it is the exposure over many years that is the concern; the relocation could happen over weeks or months. Individuals may be allowed to return within a few months if the area is to be decontaminated, but it may also be many years before individuals will be allowed to return. Individuals will have to rely on authorities for information about whether relocation is called for and how long it is likely to last.

It is extremely difficult to estimate the true implications of terrorist use of a nuclear device on a US city. The personal loss of loved ones would be immeasurable. There will certainly be economic, political, law enforcement, civil liberty, and military consequences that will likely change the very nature of the country. Medical and mental health consequences to the population directly impacted would be severe. The physical damage to the community would be extreme. The costs of the decontamination and rebuilding would be staggering. But these losses do not begin to address the true implications of this type of an incident. The detonation of a nuclear device in a US city would forever change the psyche of the population, as well as its politics and worldview.

Radioactive contamination could affect a wide area, depending on the quantity of radioactive material and weather conditions. In the case of widespread contamination, people in most of the affected areas may need to be evacuated. However, it is important not to try to leave the area or your place of shelter until city or state officials tell you that it's safe to do so. Follow their instructions when leaving.

Immediately after an emergency, essential services may be cut-off and local disaster relief and government responders may not be able to reach you right away. Even if they could reach you, knowing what to do to protect yourself and your household is essential. If you are told to remain in shelter at your home, office, or a public shelter, here are some things to keep in mind:

- Monitor the radio and television for information on assistance that may be provided. Local, state and federal governments and other organizations will help meet emergency needs and help you recover from damage and losses.
- Although it may be difficult, you should make every effort to maintain sanitary conditions in the shelter space.
- Water and food may be scarce. Use them carefully, but do not impose severe rationing, especially for children, the ill, or the elderly.
- Cooperate with each other. Living with many people in a confined space can be difficult and stressful.
- If you turned the gas, water, and electricity off at the main valves and switch before you took shelter:

  - Do not turn the gas back on. The gas company will turn it back on for you or you will receive other instructions.
  - Do not turn the water back on at the main valve until you know the water system is working and water is not contaminated.
  - Do not turn electricity back on at the main switch until you know the wiring is undamaged in your home and the community electrical system is functioning.
- Check to see that sewage lines are intact before flushing toilets.
- During the period after a radiologic or nuclear disaster, it is important to stay away from damaged areas and areas marked "radiation hazard" or "HazMat" (short for hazardous material).
- If your home was within the range of a bomb's shock wave, or you live in a high-rise or other apartment building that experienced a non-nuclear explosion, check first for any sign of collapse or damage, such as:
  - Toppling chimneys, falling bricks, collapsing walls, plaster falling from ceilings.
  - Fallen light fixtures, pictures and mirrors.
  - Broken glass.
  - Damaged chimneys or exhaust vents.
  - Ruptured gas and water mains
  - Downed electric lines.

10.1 Managing Water Supplies

Stocking water reserves should be a top priority. Drinking water in emergency situations should not be rationed. Therefore, it is critical to store adequate amounts of water for your household.

- Individual needs vary, depending on age, physical condition, activity, diet, and climate. A normally active person needs at least two quarts of water daily just for drinking. Children, nursing mothers, and ill people need more. Very hot temperatures can double the amount of water needed.
- Because you will also need water for sanitary purposes and, possibly, for cooking, you should store at least one gallon of water per person per day.

Store water in thoroughly washed plastic, fiberglass, or enamel-lined metal containers. Don't use containers that can break, such as glass bottles. Never use a container that has held toxic substances. Sound plastic containers, such as soft drink bottles, are best. You can also purchase food-grade plastic buckets or drums.

Water is critical for survival. Plan to have about one gallon of water per person per day for drinking, cooking, and personal hygiene. You may need more for medical emergencies. Allow people to drink according to their need. The average person should drink between 2 and 2-1/2 quarts of water or other liquids per day, but many people need more. This will depend on age, physical activity, physical condition and, time of year. You can minimize the amount of water your body needs by reducing activity and staying cool. Carbonated beverages do not meet drinking-water requirements. Caffeinated drinks and alcohol dehydrate the body, which increases the need for drinking water.

- Never ration water unless ordered to do so by authorities.
- Drink water that you know is not contaminated first. If necessary, suspicious water, such as cloudy water from regular faucets or muddy water from streams or ponds, can be used after

it has been treated. If water treatment is not possible, put off drinking suspicious water as long as possible, but do not become dehydrated.

- In addition to stored water, other sources include:
  - Melted ice cubes.
  - Water drained from the water heater faucet, if the water heater has not been damaged.
  - Water dipped from the flush tanks (not the bowls) of home toilets. Toilet bowl water can be used for pets.
  - Liquids from canned goods such as fruit and vegetable juices.
- If water pipes are damaged or if local authorities advise you, turn off the main water valves to prevent water from draining away in case the water main breaks. The pipes will be full of water when the main valve is closed. To use this water, turn on the faucet at the highest point in your house (which lets air into the system). Then draw water, as needed, from the lowest point in your house, either a faucet or the hot water tank.

  Unsafe water sources include:
  - Radiators
  - Hot water boilers (home heating system)
  - Water beds (fungicides added to the water or chemicals in the vinyl may make water unsafe to use)
  - Swimming pools and spas (chemicals used in them to kill germs are too concentrated for safe drinking, but can be used for personal hygiene, cleaning and related uses)

10.2 Water Treatment

Treat all water of uncertain purity before using it for drinking, food washing, or preparation, washing dishes, brushing teeth, or making ice. In addition to having a bad odor and taste, contaminated water can contain microorganisms that cause diseases such as dysentery, cholera, typhoid, and hepatitis.

There are many ways to treat water. None is perfect. Often the best solution is a combination of methods. Before treatment, let any particles settle to the bottom of the container or strain them through layers of clean cloth. Containers for water should be rinsed with a diluted bleach solution (one part bleach to ten parts water) before use. Previously used bottles or other containers may be contaminated with microbes or chemicals. Do not rely on untested devices for decontaminating water.

- If your water is treated commercially by a water utility, you do not need to treat water before storing it. Additional treatments of treated public water will not increase storage life.
- If you have a well or public water that has not been treated, follow the treatment instructions provided by your public health service or water provider.
- If you suspect that your well may be contaminated, contact your local or state health department or agriculture extension agent for specific advice.
- Seal your water containers tightly, label them and store them in a cool, dark place.
- It is important to change stored water every six months.

Four water treatment methods are generally recommended. The first three methods boiling, chlorination, and water treatment tablets will kill microbes but will not remove other contaminants such as heavy metals, salts, most other chemicals, and radioactive fallout. The fourth method, distillation will remove microbes as well as most other contaminants, including radioactive contaminants.

1. Boiling is the safer method of treating water. Boiling water kills harmful bacteria and parasites. Bringing water to a rolling boil for 1 minute will kill most organisms. Let the water cool before drinking. Boiled water will taste better if you put oxygen back into it by pouring it back and forth between two containers. This will also improve the taste of stored water.

2. Chlorination uses liquid chlorine bleach to kill most microbes such as bacteria. Use regular household liquid bleach that contains no soap or scents. Add six drops (1/8 teaspoon) of unscented bleach per gallon of water; stir, and let stand for 30 minutes. If the water does not taste and smell of chlorine at that point, add another dose and let stand another 15 minutes.

3. Water treatment "purification" tablets release chlorine or iodine. They are inexpensive and available at most sporting goods stores and some drugstores. Follow the package directions carefully. NOTE: People with liver or kidney disease may be adversely affected by iodized tablets and may experience worsened health problems as a result of ingestion. Iodized tablets are safe for healthy, physically fit adults and should be used only if supplies for boiling, chlorination, or distillation are not available.

4. Distillation involves boiling water and collecting the vapor that condenses back to water. The condensed vapor may include salt or other impurities. A simple way to distill water is to fill a pot (with a lid) halfway with water. Tie a cup to the handle on top of the lid so that the cup hangs right side up when the lid is placed back on the pot (make sure the cup is not dangling into the water). Boil for 20 minutes. The water that drips from the lid into the cup is distilled.

10.3 Managing Food Supplies

- Carefully ration food for everyone except children and pregnant women. Most people can remain relatively healthy with about half as much food as usual and can survive without any food for several days. If activity is reduced, healthy people can survive on half their usual food intake for an extended period or without any food for many days. Try to avoid foods high in fat and protein, since they will make you thirsty. Try to eat salt-free crackers, whole grain cereals and canned foods with high liquid content.
- Food items that you might consider including in your disaster supply kit include: ready-to-eat meats, fruits, and vegetables; canned or boxed juices, milk, and soup; high-energy foods like peanut butter, jelly, low-sodium crackers, granola bars, and trail mix; vitamins; foods for infants or persons on special diets; cookies, hard candy; instant coffee, cereals, and powdered milk.
- You don't need to go out and buy unfamiliar foods to prepare an emergency food supply. You can use the canned foods, dry mixes, and other staples found in your home. Canned foods do not require cooking, water, or special preparation. Be sure to include a manual can opener.
- Keep canned foods in a dry place where the temperature is fairly cool. To protect boxed foods from pests and to extend their shelf life, store the food in tightly closed plastic or metal containers.
- Replace items in your food supply every six months. Throw out any canned good that becomes swollen, dented, or corroded. Use foods before they go bad, and replace them with fresh supplies. Date each food item with a marker. Place new items at the back of the storage area and older ones in front.

- For emergency cooking, heat food with candle warmers, chafing dishes, and fondue pots, or use a fireplace. Charcoal grills and camp stoves are for outdoor use only.
- Commercially canned food can be eaten out of the can without warming. Before heating food in a can, remove the label, thoroughly wash the can, and then disinfect them with a solution consisting of one cup of bleach in five gallons of water, and open before heating.
- Do not eat foods from cans that are swollen, dented, or corroded even though the product may look okay to eat.
- Do not eat any food that looks or smells abnormal, even if the can looks normal.
- Food containers with screw-caps, snap-lids, crimped caps (soda pop bottles), twist caps, flip tops, snap-open, and home canned foods should be discarded if they may have been contaminated because they cannot be disinfected.
- For infants, use only pre-prepared canned baby formula. Avoid the use of powdered formulas with treated water.
- A refrigerator will keep foods cool for about four hours without power if it is left unopened. Thawed food usually can be eaten if it is still "refrigerator cold," or re-frozen if it still contains ice crystals. Discard any food that has been at room temperature for two hours or more, and any food that has an unusual odor, color, or texture. To be safe, remember, "when in doubt, throw it out."

10.4 Delivering First Aid

In the event of any disaster, it is prudent to be knowledgeable in the art of basic first aid techniques. The appropriate use of dressings, bandages, slings, and splints are an important part of first aid care; it is a good idea to learn and practice their application before an emergency occurs. There are many courses where you could receive this training such as your local American Red Cross Chapter or other accredited provider. A simple sequence of first aid actions when dealing with an emergency situation is to:

- Remain calm while providing the injured or ill person with first aid treatment.
- Keep the person warm and lying down. Do not move an injured person until you have discovered the extent of the injuries.
- Assess airway and breathing. Start cardiopulmonary resuscitation (CPR) immediately if the injured person is not breathing.
- Stop any bleeding. Blood may flow from a vein or an artery or both. Blood from veins is dark red and flows steadily. Blood from arteries is bright red and usually spurts from the wound. Bleeding from an artery is more critical than bleeding from a vein because blood is being pumped out at a faster rate, leading to greater blood loss. Severe bleeding from an artery can be fatal.
- Watch carefully for signs of shock. Shock is a depression of all of the body processes and may follow any injury regardless of how minor. Factors such as hemorrhage, cold and pain will intensify shock. When experiencing shock the individual will feel weak and may faint. The skin becomes cold and clammy and the pulse, weak and rapid. Shock can be more serious than the injury itself.
- Check for cuts, fractures, and breaks.
- Try not to move the person unless absolutely necessary to avoid injuring the head, neck, or spine.
- Do not remove clothing unless it is imperative.
- Decide if the person can be moved to a proper medical facility. If this is not possible, prepare a suitable living area in which shelter, heat, and food are provided

Blood and Body Fluid Exposure

Actions taken to assist an individual may raise your risk of exposure to blood and body secretions, thereby increasing your risk of exposure to human immunodeficiency virus (HIV), hepatitis B, and hepatitis C. These viruses can pass from an infected individual to a rescuer through broken skin or mucous membranes such as the eyes, nose, or mouth, or from open wounds. You can reduce your risk of exposure by wearing protective equipment such as face masks, eye shields, and gloves. With proper precautions, the risk of contracting these viruses through blood and body secretions is low.

10.5 Coping with a Radiation Disaster

Experiencing a disaster can be one of the most difficult events a person can endure, and it can have both short- and long-term effects. Everyone who sees or experiences a disaster is affected by it in some way. It is normal to feel anxious about your own safety and that of your family and close friends. You may not be able to make sense out of what happened, which is normal. There is no one way to feel after a tragic event. People should not think that there is something wrong with them for feeling a certain way or if they respond differently than others.

Everyone who experiences a disaster has different needs and different ways of coping. The emotional toll that a disaster brings can sometimes be even more devastating than the financial strains of damage and loss of one's home, business, or personal property. Even individuals who experience a disaster "second hand" through exposure to extensive media coverage can be affected. Profound sadness, grief, and anger are normal reactions to an abnormal event. Acknowledging your feelings can help you recover.

Think positive. Think about your abilities and capability to handle the situation. A positive outlook can increase your ability to perform under stressful situations and increase your resistance to negative consequences.

Control anxiety. There are many ways in which people control their anxiety. Learning relaxation techniques such as deep breathing and progressive muscle relaxation can help control the negative physical and emotional response to anxiety. Do not use drugs or alcohol to help you relax as they can have a rebound effect on anxiety, making your anxiety worse once the relaxation effect has worn off. They may also impair your judgment at a critical time when you need it most.

Stay informed. After a disaster it is important to obtain accurate information about what happened and what your community needs you to do to help or be safe. Newspapers, radio, and television are ways to get accurate local information. Do not listen to rumors as they can be misleading. Having direction after an event will likely lessen your emotional response to the event. Again, getting accurate information from reliable sources will help you know what actions and direction to take.

Stay connected. People bounce back from trauma when they feel connected and part of a team. Reconnect with loved ones, neighbors, co-workers, and others, such as through your place of worship. Attend convocations and memorial services to heal as a community.

Seek help if things get worse. Remember that feelings of anxiety and depression following a traumatic event are natural. If these symptoms continue for several weeks after the event has passed, or if these feelings begin to overwhelm you to the extent that you cannot continue your daily activities, you should consider talking to your doctor or other mental health professional. Symptoms that may indicate a need for a medical evaluation include but are not limited to:

- Changes in eating and sleeping habits
- Physical problems such as stomach upset, back and neck aches, and headaches
- Inability to focus or concentrate on routine tasks or work
- Lack of interest in previously enjoyable activities
- Extreme fear of leaving your home
- Irritability and significant mood swings
- Having flashbacks or nightmares or playing the events over and over in your mind
- Taking extreme measures to avoid the memories through the use of alcohol or other drugs
- Having extreme anxiety such as panic attacks
- Feeling hopeless, helpless, or that life is not worth living

It is possible to experience multiple symptoms at the same time. Most people who experience these symptoms will be able to return to normal functioning over time, but for a few individuals, the course is less benign. Long-term psychological effects of radiation exposure can arise years after the event. Those who have been exposed – or think they might have been exposed - may experience feelings of vulnerability, post-traumatic stress, chronic anxiety, and loss of control. Individuals also may experience fear for the safety of future generations. Affected individuals appear to fall into one of three groups:

- Those who are distressed
- Those who may exhibit behavioral changes
- Those with high risk to develop psychiatric illness.

Restoration of mental health after a disaster may be a prolonged process. Clinical management is best when an individual is diagnosed and treated soon after the event. Early intervention can minimize long-term negative psychological outcomes. Appropriate counseling may reduce health risks, work absenteeism, and chronic disease problems caused by stress and other behavioral and emotional reactions to the event. Treatment may involve the use of specific medications alone or in combination with group, family, and individual counseling therapies. Emphasis will be placed on the normal recovery process (talking to others, getting rest, and returning to normal routines) to improve health outcomes.

Children comprise a special subset of the population affected by traumatic events. The psychological impact of a disaster can be attributed to the nature of the disaster itself, the level of exposure to the event (direct, indirect), the extent to which children and those around them are personally affected, and individual characteristics of each child. Children also are affected not only by their own reaction to the trauma of the event but by their emotions and behaviors exhibited by parents and others. Because children depend on adults for their emotional and psychological needs, any effects of trauma on adults can exacerbate the psychological impact on children.

As soon as possible, children should be provided access to and encouraged to participate in normal events such as play and school. Assisting parents in their emotional responses to the event will often help their children adjust in a healthy fashion. Disasters can leave children feeling frightened, confused, and insecure. Whether a child has personally experienced trauma, has merely seen the event on television, or has heard it discussed by adults, it is important for parents and teachers to be informed and ready to help if reactions to stress begin to occur. Children may respond to disaster by demonstrating fears, sadness, or behavioral problems. Younger children may return to earlier behavior patterns, such as bedwetting, sleep problems, and separation anxiety. Older children also may display anger, aggression, school problems, or withdrawal. Some children who have only indirect contact with the disaster but witness it on television may develop distress.

Key Points to Help Cope With Disaster
• Educate yourself about the potential danger. Keep informed about breaking news and developments. If television or other news reports greatly increase your feelings of anxiety and helplessness, avoid them; you don't need every graphic detail. • Avoid overexposure to news rebroadcasts of the events. Television news of traumatic events can be particularly frightening to children, especially when it is viewed repeatedly. • Try to take control of your situation as best you can. If possible, avoid places that will cause you unnecessary stress and anxiety. If you feel anxious, angry, or depressed, realize that others are experiencing similar emotions. • Avoid being alone. Talk about your feelings with family or friends. • Reunite with friends or family, and utilize your social and community support networks. • If you have contact with children, let them know that you are there for them to talk about the disaster and their feelings. • Avoid becoming preoccupied with the disaster. Take some time to get away from your "normal" routine. Find ways to distract yourself from thinking about the event and the potential for further harm. Get involved in an activity that you can control (work in the house or garden, do volunteer work, go see a movie or play). • Maintain healthy behaviors. Eat a well-balanced diet. Avoid or at least minimize alcohol intake. Get regular exercise and adequate sleep. If you smoke, don't increase your tobacco consumption. Although it may seem to ease anxiety in the short term, smoking has significant health risks. • Learn techniques to help you relax and decrease your anxiety.

10.6 Building Resilience Through Preparation and Planning

The effects of a radiation disaster can be reduced if preparations are made ahead of time. Disaster planning is a responsibility of elected officials, business leaders, school officials, and all citizens. In a national emergency, help from outside the community may be days or even weeks away. Are you, your family, and your community prepared to respond successfully?

Healthy, resilient people have stress-resistant personalities and learn valuable lessons from rough experiences. Resilience is the process of successfully adapting to difficult or challenging life experiences. Resilient people overcome adversity, bounce back from setbacks, and thrive under extreme, on-going pressure without acting in dysfunctional or harmful ways. Resilient people experience temporary disruptions in life when faced with challenges, but are able to continue with daily tasks and remain generally optimistic about life. People who are less resilient may obsess on problems, feel victimized, and overwhelmed, and turn to unhealthy coping mechanisms, such as drugs or alcohol. They may even be more prone to develop mental health problems such as depression, anxiety, or post-traumatic stress disorder.

In physics, resiliency refers to the ability of a material to return quickly to its original form after being bent, stretched, or twisted. Psychological resiliency is a similar concept. It is the ability of people to return to normal by bouncing back from the ups-and-downs of life. Individuals can build resilience by taking responsibility for their physical and psychological health. Additional ways to strengthen personal resilience include building healthy relationships with family and friends and community groups, accepting and anticipating change, and taking action toward positive goals that can keep the mind focused.

Local businesses, churches, schools, and other organizations bring individuals together that know each other and can be a great strength in mobilizing community action. All of these groups need to be part of local disaster planning. The more diverse the community the greater the challenges, but with planning and cooperation a coordinated response will save lives and speed recovery. Knowing what to expect in a radiation disaster will help you plan more effectively. Being prepared increases your sense of control, and will allow you to help others understand the potential impact of radiation exposure.

Take time to prepare a personal and family disaster plan. Know the emergency plans where you work, at school, and for your community. Be prepared so you can recognize and respond effectively to potentially dangerous situations. Consider volunteering with a recognized organization involved in disaster response and recovery prior to the next disaster event. There are many organizations and faith-based groups in the community that have active disaster programs and need volunteers. These groups offer a wide range of services following a disaster: Consider participating in the Citizen Corps or other local volunteer organization in your community. If you don't have a Citizen Corps Council in your area, contact your state Citizen Corps representative and work with your local officials to get one started.

Recognize that regardless of your training, you can participate in disaster preparedness activities that are going on in your community right now. Across the United States, community leaders and citizen volunteers are working on the development and refinement of local plans that will be used in the event of a local or national emergency. These hometown meetings serve as an opportunity to meet with state and national emergency response partners who will be working with your community in an emergency and to learn about their preparations and plans. Everyone who is interested can and should have a part in ongoing community planning efforts. When it comes to understanding the unique strengths and weaknesses of your community, there is no greater expert than you. Your knowledge and views are unique and valued. The more you know, the better able you will be to protect yourself and your community in the event of a serious disaster or other public health emergency. The bottom line is to get prepared and be ready!

Take Home Messages
• After a release of radioactive materials, local authorities will monitor the levels of radiation and determine what protective actions to take. • The most appropriate action will depend on the situation. Stay tuned to the local emergency response network or news station for up-to-date information and instructions. • If a radiation emergency involves the release of large amounts of radioactive materials, you may be advised to “shelter-in-place,” which means to stay in your home or office, or you may be advised to move to another location. • If you are instructed to remain in your home or office building, you should: - Close doors and windows and turn off all ventilation, including furnaces, air

conditioners, vents, and fans.
  - Seek shelter in an internal room and take your disaster supplies kit.
  - Listen to local news stations for further instructions from authorities.
- The longer a person is exposed to radiation, the greater the dose; casualties should be removed from the disaster scene as quickly as possible.
- The farther away you are from a radiation source, the lower the radiation dose.
- The health effects of radiation exposure are directly related to the amount of radiation absorbed by the body (radiation dose) and are determined by the:
  - Radiation type (alpha, beta, x-ray, or gamma radiation);
  - Means of exposure, internal or external (absorbed by the skin, inhaled, or ingested); and
  - Length of time exposed.
- Emergency responders should wear protective gloves, protective clothing, and radiation dosimeters (devices that measure amounts of radiation exposure); respirators or protective masks can prevent breathing in radioactive particles.
- Decontaminate by removing clothing and showering. Removal of clothing and washing with soap and large amounts of water are sufficient to remove most external radiation contamination.
- People being examined for potential radiation exposure may not show obvious symptoms when first examined (even if they received a large radiation dose) due to the delayed onset of symptoms following exposure. Follow-up medical examination is needed to establish the true nature and extent of exposure.
- For exposure to radioactive iodine (for example, a nuclear power plant incident), potassium iodide (KI) is given to protect the thyroid gland. KI will not protect a person from other radioactive materials or protect other parts of the body from radiation exposure.

The most important thing is to plan and prepare in advance. Become better educated and informed about these events, and get answers to questions you have to best help yourself and support others during potentially stressful and difficult times.

11.0 For More Information

Personal preparedness resources can be found on the websites of most state and local public health and emergency management agencies. The following agencies, organizations, and Internet sites also provide helpful information for your disaster planning needs:

11.1 Government Resources

Centers for Disease Control and Prevention (www.cdc.gov)
Part of the U.S. Department of Health and Human Services, the CDC is a comprehensive and authoritative resource on medical and public health issues for health professionals and citizens worldwide. The website is updated frequently to provide reliable information quickly.

Citizen Corps Program (www.citizencorps.gov)
The Citizen Corps asks everyone to take personal responsibility to be prepared; to get training in first aid and emergency skills; and to volunteer to support local emergency responders, disaster relief, and community safety. Currently there are more than 2,300 Citizen Corps Councils in the United States.

- Community Emergency Response Team (CERT) Program (www.citizencorps.gov/cert/)

Federal Emergency Management Agency (www.fema.gov)
FEMA, which is part of the U.S. Department of Homeland Security, is the lead federal agency responsible for reducing the loss of life and property and protecting communities from disasters.

- DisasterHelp (www.disasterhelp.gov)
- FEMA for Kids (www.fema.gov/kids)

National Library of Medicine (www.nlm.nih.gov/)
The National Library of Medicine (NLM), on the campus of the National Institutes of Health in Bethesda, Maryland, is the world's largest medical library. The Library collects materials and provides information and research services in all areas of biomedicine and health care.

- Radiation Emergency Management (www.remm.nlm.gov/)

National Oceanic and Atmospheric Administration (www.noaa.gov)
NOAA is the federal agency responsible for monitoring and increasing understanding of the role of the oceans, coastal areas, and the atmosphere in the global ecosystem, as well as for conserving and managing coastal and marine resources to meet national economic, social, and environmental needs.

- National Weather Service (www.nws.noaa.gov)

Nuclear Regulatory Commission (www.nrc.gov)
NRC is an independent regulatory agency created out of the Atomic Energy Commission in 1975 to regulate the civilian uses of nuclear material. The NRC is responsible for ensuring that a civilian nuclear activities are carried out with adequate protection of the public health and safety, the environment, and national security:

Oak Ridge Radiation Emergency Assistance/Training Site (www.orau.gov/reacts)
The Oak Ridge Institute for Science and Education (ORISE) is a U.S. Department of Energy (DOE) institute managed by Oak Ridge Associated Universities (ORAU). ORISE addresses national needs by (1) assessing and analyzing environmental and health effects of radiation and other hazardous materials; (2) maintaining medical and national security radiation emergency management and response capabilities; and (3) managing education programs to help ensure a robust supply of scientists, engineers and technicians to meet future science and technology needs.

Substance Abuse and Mental Health Services Administration (www.samhsa.gov)
Part of the U.S. Department of Health and Human Services, SAMHSA focuses on building resilience and facilitating recovery for people with or at risk for mental or substance use disorders.

U.S. Department of Energy (www.energy.gov/)
The mission of the Department of Energy is to ensure U.S. security and prosperity by addressing its energy, environmental, and nuclear needs and challenges through science and technology.

U.S. Department of Health and Human Services (www.dhhs.gov)
HHS is the U.S. government's principal agency for protecting the health of all Americans and providing essential human services, especially for those who are least able to help themselves.

U.S. Department of Homeland Security (www.dhs.gov)
The DHS leads the unified national effort to secure the country against terrorism and other disasters.

- Ready.gov campaign (www.ready.gov)

U.S. Environmental Protection Agency (www.epa.gov/)
The EPA works to protect significant risks to human health and the environment based on the best available scientific information, and ensure that federal laws protecting human health and the environment are enforced fairly and effectively.

U.S. Food and Drug Administration (www.fda.gov/)
The FDA's primary responsibility is to protect the American people from unsafe or mislabeled food, drugs, and other medical products and to make sure consumers have access to accurate, science-based information about these products. The agency also guides and oversees the development and availability of new medical products and new food products to improve the health and well-being of American consumers.

11.2 Professional Associations and Volunteer Organizations

American Academy of Pediatrics (www.aap.org)
The AAP is a medical specialty society devoted to attaining optimal physical, mental, and social health and well-being for all infants, children, adolescents, and young adults.

- Children and Disasters (www.aap.org/disasters)

American Association of Poison Control Centers (www.aapcc.org/DNN)
The AAPCC maintains a 24-hour "Poison Help" hotline (1-800-222-1222) that is continuously staffed by pharmacists, physicians, nurses, and poison information providers who are toxicology specialists. The Poison Help hotline provides immediate access to exposure management instructions and information on potential poisons. The public may use the number to ask questions about the proper handling and ventilation related to household products, bites and stings, plants, over-the-counter and prescription medications, drugs, alcohol, hydrocarbons, carbon monoxide and other types of potentially toxic fumes and gases.

American Medical Association (www.ama-assn.org)
The AMA is a national professional association of physicians who are dedicated to working on the most important medical and public health issues affecting doctors and their patients.

- Center for Public Health Preparedness and Disaster Response (www.ama-assn.org/go/disasterpreparedness)

American Nuclear Society (www.new.ans.org)

The American Nuclear Society is a not-for-profit, international, scientific, and educational organization dedicated to unifying professional activities within the diverse fields of nuclear science and technology.

American Public Health Association (www.apha.org)
The APHA is a professional association representing a variety of health professions and others who are dedicated to protecting individuals and their communities from preventable, serious health threats; and assuring that community-based health promotion and disease prevention activities and preventive health services are accessible throughout the United States.

- APHA Get Ready Campaign (www.getreadyforflu.org/newsite.htm)

American Red Cross (www.redcross.org)
The American Red Cross website and offices nationwide have excellent resources for answering questions and walking citizens through appropriate disaster preparation steps. Many of their materials are available in multiple languages.

Association of State and Territorial Health Officials (www.astho.org)
ASTHO is the national nonprofit organization representing the public health agencies of the United States, the U.S. territories, and the District of Columbia. ASTHO members, the chief health officials of these jurisdictions, formulate and influence public health policy to assure excellence in state-based public health practice.

Conference of Radiation Control Program Directors (www.crcpd.org)
The CRCPD is a nonprofit non-governmental professional organization dedicated to promoting radiation protection issues, encouraging high standards of quality in radiation protection programs, and providing leadership in radiation safety and education. CRCPD's primary membership includes radiation professionals in state and local government that regulate the use of radiation sources.

Council of State and Territorial Epidemiologists (www.cste.org/dnn/)
CSTE is an organization of member states and territories representing public health epidemiologists. It provides technical advice and assistance to partner organizations and to federal public health agencies such as the Centers for Disease Control and Prevention (CDC) on topics such as occupational health, infectious diseases, immunization, environmental health, chronic diseases, injury control, and maternal and child health. CSTE promotes the use of effective public health surveillance and good epidemiologic data to guide public health practice and improve health.

Health Physics Society (www.hps.org)
The Health Physics Society is a scientific organization of professionals who specialize in the science and practice of radiation safety. Its members represent all scientific and technical fields related to radiation safety including academia, government, medicine, research and development, analytical services, consulting, and industry in all 50 states and the District of Columbia.

National Association of County and City Health Officials (www.naccho.org)
NACCHO is the national organization representing local health departments. It supports efforts to protect and improve the health of all people and all communities by promoting

national policy, developing resources and programs, seeking health equity, and supporting effective local public health practice and systems.

National Emergency Management Association (www.nemaweb.org)
NEMA is a nonprofit association dedicated to enhancing public safety by improving the nation's ability to prepare for, respond to, and recover from all emergencies, disasters, and national security threats. It is the professional association of and for emergency management directors from all 50 states, eight U.S. territories, and the District of Columbia.

National Voluntary Organizations Active in Disaster (www.nvoad.org)
NVOAD is a coalition of nonprofit organizations that respond to disasters as part of their overall mission.

11.3 State and Local Directories

Federal Bureau of Investigation Field Offices (www.fbi.gov/contact/fo/fo.htm#cities)

Local Public Health Agencies (www.naccho.org/about/LHD)

State Public Health Agencies (www.cdc.gov/mmwr/international/relres.html)

State Emergency Management Offices (www.fema.gov/about/contact/statedr.shtm)

12.0 Glossary

Absorbed dose. The amount of energy deposited by ionizing radiation in a unit mass of tissue is called radiation absorbed dose. It is expressed in units of joule per kilogram (J/kg), and is recognized internationally as the standard name 'gray' (Gy). A more conventional unit of absorbed dose, used mostly in the United States, is the rad. [100 rad equals 1 Gy; or 1 Gy equals 0.01 rad].

Activity (radioactivity). The rate of decay of radioactive material expressed as the number of atoms breaking down per second measured in units called becquerels or curies.

Acute exposure. A single exposure that results in biological harm or death; usually characterized by a brief exposure lasting no more than 7 days, as compared to longer, continuing exposure over a period of time

Acute radiation syndrome (ARS). A serious illness caused by receiving a large dose of radiation energy that penetrates the body within a short time period (usually minutes). The first symptoms include nausea, vomiting, and diarrhea starting within minutes to days after the exposure and lasting for minutes to several days; these symptoms may come and go. Then the person usually looks and feels healthy for a short time, after which he or she will become sick again with loss of appetite, fatigue, fever, nausea, vomiting, diarrhea, and possibly even seizures and coma. This seriously ill stage may last from a few hours to several months. Clinically, ARS is very difficult to diagnose in the absence of any other radiologic information from the incident scene because symptoms within the first few hours after exposure are no different from common diarrhea, vomiting, and nausea. Proper diagnosis of exposure to ionizing radiation (no contamination) and an estimate of the total dose can only be achieved by analysis of the complete blood count (CBC), chromosome aberration cytogenetic bioassay, and consultation with radiation experts.

Alpha particle. One of the primary ionizing radiations, the others being beta particles, gamma-rays, x-rays, and neutrons. Alpha particles can be stopped by a thin layer of light material, such as a sheet of paper, and cannot penetrate the outer, dead layer of skin. They do not pose a hazard as long as they are outside the body. Protection from this radiation is directed to preventing, or at least minimizing, inhalation or ingestion of the radioactive material. Alpha particles are difficult to detect in an accidental situation because they penetrate only a few inches in air, and most "general purpose" detection instruments are poorly suited to this particular detection scheme. If radiation is detected at an incident scene, instruments should be brought in as quickly as possible to determine whether alpha emitting radioisotopes are present.

Background radiation. This is the radiation that the population is naturally and continually exposed to from natural sources. It consists of radiation from natural sources of radioactivity such as those found in soil, rocks, the air, our bodies, and our food, as well cosmic radiation originating in outer space.

Becquerel (Bq). The SI unit describing the amount of radioactivity. One Bq is the amount of a radioactive material that will undergo one decay (disintegration) per second, a very small rate. Industrial sources of radioactivity are normally described in terms of gigabequerels (GBq), or one billion Bq. The conventional unit for radioactivity is the curie (Ci). [1 Ci is equal to 3.7×10^{10} Bq]

Beta particles. One of the primary ionizing radiations, the others being alpha particles, gamma-rays, x-rays, and neutrons. They travel only a few feet in air and can be stopped by a thin sheet of aluminum. However, beta particles can penetrate the dead skin layer and, if present in large amounts or long period of time, cause skin burns. Protection from this radiation is directed toward washing the skin with mild soap and water and preventing, or at least minimizing, inhalation or ingestion of the radioactive material. Beta particles are easier to detect than alpha particles. While most "general purpose" detection instruments can detect beta particles, the instrument must be within a few yards of a sizeable source. Fortunately, the vast majority of beta-emitting radioisotopes release high-energy gamma rays that can be detected at distances of tens of yards. When radiation is detected at an incident scene, proper instruments should be brought in as quickly as possible to determine whether pure beta-emitting radioisotopes are present or not, followed in turn by alpha monitoring equipment.

Bioassay (radiobioassay). An assessment of radioactive materials that may be present inside a person's body through direct analysis of the radioactivity in a person's blood, urine, feces, or sweat, or by detection methods to monitor the radiation emitted from the body.

Biologic half-life. Once an amount of radioactive material has been taken into the body, this is the time it takes for one half of that amount to be expelled from the body by natural metabolic processes, not counting radioactive decay.

Chronic exposure. Exposure to a substance over a long period of time, possibly resulting in adverse health effects.

Contamination (radioactive). The deposit of unwanted radioactive material on the surfaces of structures, areas, objects, or people (where it may be external or internal). External contamination occurs when radioactive material is outside of the body, such as on a person's skin. Internal contamination occurs when radioactive material is taken into the body through breathing, eating, or drinking.

Curie (Ci). The conventional unit describing the amount of radioactivity. See Becquerel (Bq).

Cutaneous radiation syndrome (CRS). The complex syndrome resulting from significant skin exposure to radiation. The immediate effects can be reddening and swelling of the exposed area (like a severe burn), blisters, ulcers on the skin, hair loss, and severe pain. Very large doses can result in permanent hair loss, scarring, altered skin color, deterioration of the affected body part, and death of the affected tissue (requiring surgery).

Decontamination. Removal of radioactive materials from people, materials, surfaces, food, or water. For people, external decontamination is done by removal of clothing and washing the hair and skin. Internal decontamination is a medical procedure.

Decay, radioactive. The decrease in the amount of any radioactive isotope with the passage of time due to the spontaneous emission of radiation from the atomic nuclei (either alpha or beta particles, often accompanied by gamma radiation), and consequent transformation to a different chemical form.

Dirty bomb. A device designed to spread radioactive material by conventional explosives when the bomb explodes. A dirty bomb kills or injures people through the initial blast of the conventional explosive and spreads radioactive contamination over a possibly large area—hence the term "dirty." Such bombs could be miniature devices or large truck bombs. A dirty bomb is much simpler to make than a true nuclear weapon. See discussion on radiological dispersal device (RDD) in the document.

Dose rate meters. Instruments that measure the radiation dose delivered per unit of time.

Dosimeter. Small portable instrument (such as a film badge, thermoluminescent, or pocket dosimeter) for measuring and recording the total accumulated personal dose of ionizing radiation.

Dosimetry. Assessment (by measurement or calculation) of radiation dose.

Effective half-life. The time required for the amount of a radioactive material deposited in a living organism to be diminished by 50% as a result of the combined action of radioactive decay and biologic elimination. See also biologic half-life and radioactive half-life.

Electromagnetic pulse (EMP). A nuclear weapon detonated in or above the earth's atmosphere can create an EMP, a high-density electrical field, which can seriously damage electronic devices connected to power sources or antennas. This includes communication systems, computers, electrical appliances, and motor vehicle and aircraft ignition systems. The damage could range from a minor interruption to actual burnout of components.

Exposure (irradiation). This occurs when radiation energy penetrates the body. Exposure to very large doses of radiation may cause death within a few days or months. Exposure to lower doses of radiation may lead to an increased risk of developing cancer or other adverse health effects later in life. Compare with contamination.
Fallout, nuclear. The slow descent of minute particles of radioactive debris in the atmosphere following a nuclear explosion.
Gamma rays. One of the primary ionizing radiations, the others being alpha particles, beta particles, x-rays, and neutrons. Different from alpha and beta particles, gamma-rays are very similar to x-rays and pose an external radiation hazard. Gamma-rays are highly penetrating (up to tens of yards in air). Gamma rays also penetrate tissue farther than do beta or alpha particles. Gamma-rays are relatively easy to detect with commonly available radiation detection instruments.
Geiger counter. Geiger-Mueller or GM counters are the most widely recognized and commonly used portable radiation detection instruments. The modern pancake GM detector can detect gamma, beta, and to a limited extent, alpha contamination. The sensitivity of various GM probes varies markedly. For example, an old civil defense instrument and a modern instrument will record very different readings when used side by side. Knowledgeable and experienced radiation protection specialists should interpret the measurement results.
Genetic effects. Hereditary effects (mutations) that can be passed on through reproduction because of changes in sperm or ova.
Gray (Gy). A unit of measurement for absorbed dose. It measures the amount of energy absorbed in a material. The unit Gy can be used for any type of radiation, but it does not describe the biological effects of the different radiations.
Half-life (radioactive). The time it takes for any amount of radioactive material to decay (and reduce) to half of its original amount. See also biologic half-life, effective half-life, radioactive half-life.
Health physics. A scientific field that focuses on protection of humans and the environment from radiation. Health physics uses physics, biology, chemistry, statistics, and electronic instrumentation to help protect people from any potential hazards of radiation.
Intake. Amount of radioactive material taken into the body by ingestion, inhalation, or absorption through the skin, via wounds or injection.
Ionizing radiation. Any radiation capable of displacing electrons from atoms, thereby producing ions. High doses of ionizing radiation may produce severe skin or tissue damage.
Irradiation. Exposure to radiation. See exposure and compare with contamination.
Latent period. The time between exposure to a toxic material and the appearance of a resultant health effect.
Neutron. One of the primary ionizing radiations, the others being alpha particles, beta particles, gamma-rays, and x-rays. Neutrons are highly penetrating and are a radiation hazard at the instance of a nuclear detonation. In almost all other scenarios, it is unlikely for public health officials to encounter neutron radiation or contamination. Detection of neutrons requires specialized equipment.
Penetrating radiation. Radiation that can penetrate the skin and reach internal organs and tissues. Photons (gamma rays and x-rays), neutrons, and protons are penetrating radiations. Alpha particles and all but extremely high-energy beta particles are not considered penetrating radiation.
Plume. A cloud, gas, or vapor that carries radioactive material released into the atmosphere away from the incident site in the direction of the wind. Making plume concentration predictions with time after the incident is necessary to determine whether affected populations should shelter in place or evacuate. Plume predictions use mathematical models and, although very helpful, are prone to inherent uncertainties.

Prenatal radiation exposure. Radiation exposure to an embryo or fetus while it is still in its mother's womb. At certain stages of the pregnancy, the fetus is particularly sensitive to radiation, and the health consequences could be severe above certain radiation dose levels.
Rad (radiation absorbed dose). See absorbed dose.
Radiation. Energy moving in the form of particles or waves. Familiar radiations are heat, light, radio waves, and microwaves. Ionizing radiation is a very high-energy form of electromagnetic radiation.
Radiation sickness. See acute radiation syndrome (ARS).
Radioactive contamination. See contamination.
Radioactive decay. The spontaneous disintegration of the nucleus of an atom.
Radioactive half-life. See half-life.
Radioactive material. Material that contains unstable (radioactive) atoms that give off radiation as they decay.
Radioactivity. The process of spontaneous transformation of the nucleus, generally with the emission of alpha or beta particles that are often accompanied by gamma rays. This process is referred to as decay or disintegration of an atom. See activity.
Radiobioassay. See bioassay.
Radiological or radiologic. Related to radioactive materials or radiation. The radiologic sciences focus on the measurement and effects of radiation.
Rem (roentgen equivalent, man). A conventional unit for a derived quantity called radiation dose equivalent. One rem equals 0.01 Sieverts (Sv). See Sievert.
Roentgen (R). A unit of exposure to x-rays or gamma rays.
Shielding. The material between a radiation source and a potentially exposed person that reduces his or her exposure.
Sievert (Sv). The SI unit for a derived quantity called radiation dose equivalent. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. Dose equivalent is often expressed as millionths of a sievert, or microsieverts (µSv). One sievert is equivalent to 100 rem.
SI units. The Systeme Internationale (or International System) of units and measurements. This system of units officially came into being in October 1960 and has been adopted by nearly all countries, although the amount of actual usage varies considerably.
Whole body exposure. An exposure of the body to radiation, in which the entire body, rather than an isolated part, is irradiated

Appendix A

Components of a Disaster Kit

The basic items that should be in a disaster supply kit are water, food, first aid supplies, tools and emergency supplies, clothing and bedding, and specialty items. It will be important to assemble these items in case you have to leave your home quickly. Even if you don't have to leave your home, if you lose power it will be easier to have these items already assembled and in one place.

You will need to change the stored water and food supplies every six months, so be sure to write the date you store it on all containers. You should also re-think your needs every year and update your kit as your household changes. Keep items in airtight plastic bags and put your entire disaster supply kit in one or two easy-to-carry containers such as an unused trash can, camping backpack, or duffel bag.

- Food with a long shelf life (eg, canned, dried, and packaged food products)—Store enough food for each member of the household for at least 3 days.
- Water—In preparation for a disaster, purchase and store bottled water or simply store water from the tap. Each person in the household will need about 1 gallon per day; plan on storing enough water for at least 3 days.
- A change of clothes and shoes—Check clothing every 6 months and remove clothes that no longer fit or are unsuitable for seasonal weather. Remember to include underwear, socks, sturdy shoes or work boots, and winter or summer clothes as needed. Also include rain gear and sunglasses.
- Paper plates, paper towels, and plastic utensils—Store disposable dishware and utensils because you will not have enough water to wash dishes and because community water sources may be contaminated.
- Plastic bags—Because you may not be able to leave your shelter for several days, you will need to collect your waste in plastic bags until it can be removed.
- Bedding—Blankets, pillows, or a sleeping bag for each household member. Store sheets, blankets, towels, and cots for use during the time that you cannot leave your shelter.
- Battery-operated radio and batteries—Electrical power may not be on for several days. A battery-operated radio will allow you to listen to emergency messages.
- Battery-operated travel alarm clock
- Medicines—Have 2-3 days' dose of your current prescription medicines in a childproof bottle for your shelter medical kit; label with the name and expiration date of the medicine. It may be difficult to obtain prescription medications during a disaster because stores may be closed or supplies may be limited. Ask your physician or pharmacist about storing prescription medications. Be sure they are stored to meet instructions on the label and be mindful of expirations dates be sure to keep your stored medication up to date. Discuss with your doctor the best way to obtain this small amount of extra medicine. Be sure to check medicines in your kit every 6 months to make sure they are not past the expiration date.
- Toiletries—Keep a supply of soap, hand sanitizer, toilet paper, deodorant, disinfectants, and other personal care products.
- Flashlight and batteries—Electrical power may be out for several days. A flashlight will help you see in your shelter.
- Signal flare
- Matches in a waterproof container (or waterproof matches)
- Tools to shut off your home's electricity, gas, and water supplies at main switches and valves (usually adjustable pipe and crescent wrenches)

- Duct tape and heavy plastic sheeting—You can use these items to seal the door to your shelter and to seal any vents that open into your shelter for a short period of time if a radiation plume is passing over.
- Whistle
- Small canister, A-B-C-type fire extinguisher
- Small tent
- Compass
- Work gloves
- Paper, pens, and pencils
- Needles and thread
- Kitchen items:
  - Manual can opener
  - Mess kits or paper cups, plates, and plastic utensils
  - All-purpose knife
  - Household liquid bleach to treat drinking water
  - Sugar, salt, pepper
  - Aluminum foil and plastic wrap
  - Re-sealing plastic bags
  - If food must be cooked, small cooking stove and a can of cooking fuel
- A telephone or cell phone—Although cell phone or ground phone service may be interrupted, there is still a chance that you will be able to use a phone to call outside for information and advice from emergency services.
- Extra eyeglasses or contact lenses and cleaning supplies.

First aid kit—You can purchase a first-aid kit or prepare one yourself. Keep a kit in your home and in each or your motor vehicles. Be sure to include the following basic items:
- First aid manual
- Sterile adhesive bandages in assorted sizes
- Sterile gauze pads in 2 inch and 4 inch sizes
- Triangular bandages (3)
- 2-inch and 3-inch sterile rolled bandages (3 rolls each)
- Adhesive tape
- Cotton balls
- Scissors
- Tweezers
- Needle
- Thermometer
- Moistened towelettes
- Tongue depressor blades (2)
- Cleansing agents (isopropyl alcohol, hydrogen peroxide)/soap/germicide)
- Antibiotic ointment
- Petroleum jelly or other lubricant
- Soap or hand sanitizer
- Latex or vinyl gloves (2 pairs)
- Safety pins in assorted sizes
- Aspirin or aspirin-free pain reliever
- Antidiarrhea medication
- Laxatives
- Antacids for stomach upset

- Sunscreen

Sanitation and hygiene items:
- Washcloth and towel
- Towelettes, soap, hand sanitizer, liquid detergent
- Toothpaste, toothbrushes, shampoo, deodorants, comb and brush, razor, shaving cream, lip balm, sunscreen, insect repellent, contact lens solutions, mirror, feminine supplies
- Heavy-duty plastic garbage bags and ties for personal sanitation uses and toilet paper
- Medium-sized plastic bucket with tight lid
- Disinfectant and household chlorine bleach
- Consider including a small shovel for digging a latrine

Specialty items
Remember to consider the needs of infants (eg, formula, diapers), elderly persons, disabled persons, and pets and to include entertainment and comfort items for children (books, games, quiet toys, and stuffed animals). Because you may be in a shelter for several days, keep items on hand to occupy your family during that time. Children are likely to get bored if they have to stay in one place for long periods. Think of activities that they will enjoy doing while in the shelter (eg, finger painting, coloring, playing games).

Household documents and contact numbers
- Personal identification, cash (including change) or traveler's checks, and a credit card
- Copies of important documents: birth certificate, marriage certificate, driver's license, social security cards, passport, wills, deeds, inventory of household goods, insurance papers, immunizations records, bank and credit card account numbers, stocks and bonds. Be sure to store these in a watertight container.
- Emergency contact list and phone numbers
- Map of the area and phone numbers of places you could go
- An extra set of car keys and house keys

Appendix B

Emergency Notification Form

Ambulance (local emergency medical dispatch number)____

Police department ____

Fire department ____

Local poison control center____

Local health department ____

State health department____

Hospital emergency department____

Physician____

Physician ____

Psychiatrist or other mental health professional____

24-hour pharmacy ____

Other neighborhood pharmacy ____

Health insurance number ____

Work number ____

Work number ____

Dentist ____

Babysitter ____

School____

School____

Day care center____

Veterinarian____

Electric company ____

Gas company ____

Water company ____

Neighbor ____

Neighbor ____

Relative ____

Relative ____

Other ____