Superfund Radiation Fact Sheet

What is Superfund? **The Superfund program is administered by U.S. Environmental Protection Agency (EPA) in cooperation with state and tribal governments. It allows EPA to clean up hazardous waste sites and to force responsible parties to perform cleanups or reimburse the government for cleanups led by EPA.**

For a variety of reasons, hazardous commercial and industrial wastes were mismanaged and may pose unacceptable risks to human health and the environment. This waste was dumped on the ground or in waterways, left out in the open, or otherwise improperly managed. As a result, thousands of hazardous waste sites were created throughout the United States. These hazardous waste sites commonly include manufacturing facilities, processing plants, landfills, and mining sites.

Superfund was established in 1980 by an act of Congress, giving EPA the funds and authority to clean up polluted sites

Goals of Superfund:

- **Protect human health and the environment by cleaning up polluted sites**
- **Involve communities in the Superfund process**
- **Make responsible parties pay for work performed at Superfund sites**

Superfund is the informal name for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). In 1980, Congress enacted CERCLA in response to growing concerns over the health and environmental risks posed by hazardous waste sites. This law was enacted in the wake of the discovery of chemically contaminated toxic waste dumps such as Love Canal and Valley of the Drums in the 1970s.

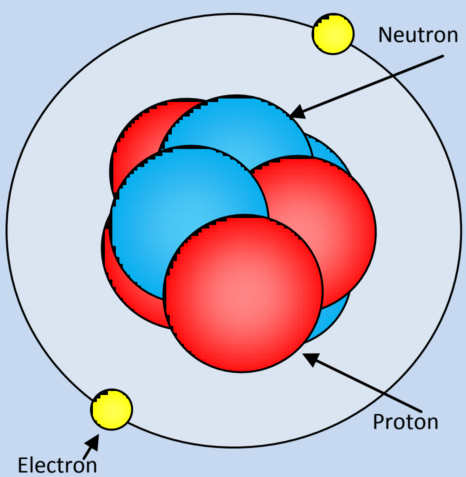
Some Superfund sites contain radioactive contamination. This document was developed by EPA to answer questions about radiation hazards and how EPA assesses health risks from potential exposure to radioactive contamination at Superfund sites.

What are atoms?

To understand radiation and radioactivity, it is important to understand atoms.

Atoms are the very small particles that make up our bodies and everything around us. Atoms consist of a central nucleus made up of protons and neutrons. Protons are positively charged, while neutrons have no charge. Electrons have a negative charge and orbit (or go around) the nucleus. Most atoms are neutral, which means they have the same number of protons and electrons. Atoms that are not neutral are called ions.

Atomic Structure



An atom consists of a central nucleus (made of protons and neutrons) orbited by electrons

An element is a specific type of atom. All atoms of an element have the same number of protons. For example, all atoms of oxygen have eight protons, while all uranium atoms have 92 protons. It is possible for atoms of the same element to have different numbers of neutrons. These various forms are called isotopes. For example, while all atoms of oxygen have eight protons, isotopes of oxygen can have from four to 16 neutrons.

What is Radiation?

Radiation is energy that travels in the form of waves or high-speed particles. There are two types of radiation:

- **Non-ionizing radiation** is low energy. It includes radio waves, microwaves, and visible light. Non-ionizing radiation can generate heat, but it does not have enough energy to remove electrons from atoms.
- **Ionizing radiation** is high energy. It can remove tightly bound electrons from an atom. Ionizing radiation can be harmful to humans by damaging living tissue and increasing cancer risk. X-rays are a familiar form of ionizing radiation.

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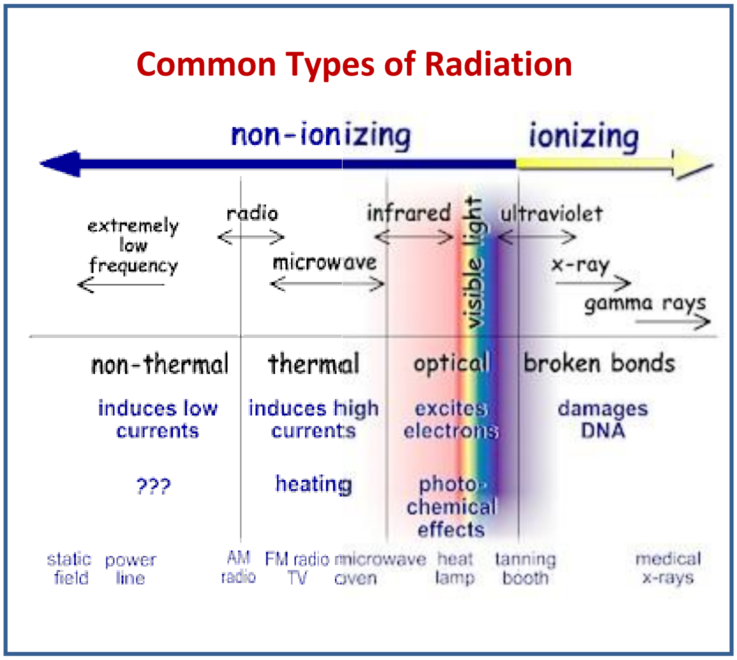
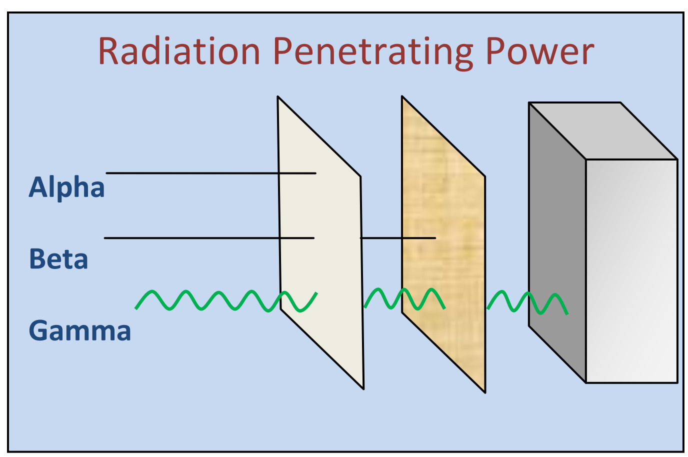


In this fact sheet, the term "radiation" will mean ionizing radiation.

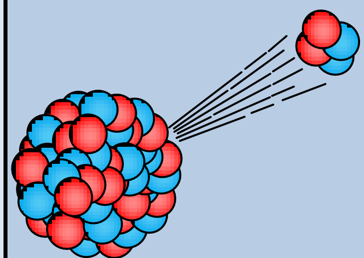
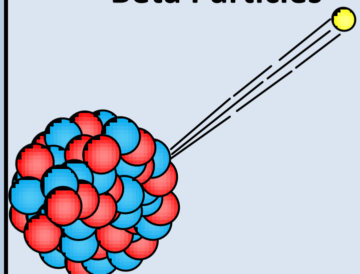
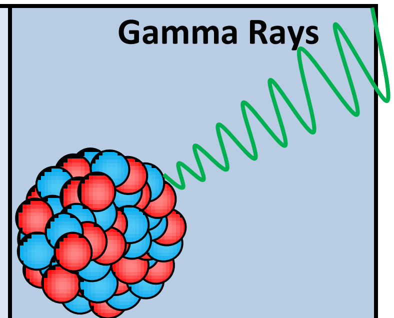
What is Radioactivity?

Some isotopes of certain atoms are unstable. When these unstable atoms release ionizing radiation in the form of waves or particles, it is called **radioactivity**. A radioactive atom is called a **radionuclide**. When a radionuclide emits (gives off) radiation, it is said to **decay**. There are three main types of radiation given off when a radionuclide decays:

- **Alpha particles** are heavy, relatively slow moving, particles. They can be blocked by a piece of paper or by skin. However, radionuclides that give off alpha particles can be very harmful if they enter your body in other ways such as through the air, food, or water because your internal organs are not protected by skin.
- **Beta particles** are light weight, relatively fast moving particles. They can be blocked by a thin piece of metal or wood. Beta particles can penetrate (pass through) the outer layer of skin and cause radiation burns. Like alpha particles, beta particles can damage your health if they enter your body.
- **Gamma rays** are waves of pure energy that often accompany beta and alpha particles. Gamma rays can pass through the body and damage internal organs. A thick wall of metal or concrete is needed to absorb gamma radiation.



Ionizing Radiation Found at Superfund Sites

	Alpha Particles	Beta Particles	Gamma Rays
			
Description	• Two protons and two neutrons bound together into a single particle • Heaviest and slowest moving type of ionizing radiation • Positively charged	• Made up of an electron ejected from nucleus • Fast moving, low mass particle • Negatively charged	• Pure energy traveling at the speed of light • Often accompanies the emission of alpha or beta particles • Has no rest mass and no charge
Ionizing Power	• **HIGH** • Interacts strongly with surrounding material • Very energetic	• **MODERATE** • Interact less strongly than alpha particles but more strongly than gamma rays with surrounding material	• **LOW** • Since they have no mass and no charge, gamma rays interact with matter less than alpha and beta particles
Penetrating Power	• **LOW** • Travels no more than a few centimeters in air • Can be stopped by a sheet of paper • Unable to penetrate skin	• **MODERATE** • Able to travel several meters through air • Can be stopped by a thin layer of metal or plastic • Can penetrate outer layers of skin	• **HIGH** • Able to travel hundreds of meters through air • Can be stopped by a thick concrete wall • Able to pass through the human body
Human Health Effects	• No health effects from external exposure since they are unable to penetrate skin • Very harmful if alpha-emitting radionuclide is taken into the body by ingestion,r breathing, or through an open wound	• Can cause skin burns from external exposure • Harmful if taken into the body (though not usually as harmful as alpha particles)	• Can cause harm from external exposure • Can pass into the body and cause internal radiation exposure

What happens to radionuclides as they decay?

As radionuclides decay, they become new elements called **daughter products**, which are also known as decay products**.** These daughter products may or may not be radioactive themselves. If a daughter product is also radioactive, it in turn will decay to form a different daughter product. This process will continue until a stable, nonradioactive product is formed. The radioactive decay of a radionuclide and all of its daughters is known as a **decay chain.**

What is half-life?

The rate a radionuclide decays is its **half-life**. Half-life is defined as the amount of time it takes for half of the amount of a substance to emit radiation and change to a different substance. Radionuclide half-lives can be very long or very short. For example, uranium-238 has a half-life of 4.5 *billion* years, while carbon-11 has a half-life of only a few minutes.

How is radioactivity measured?

Radioactivity is measured by the **activity** of a material. The activity is the number of radionuclides that decay each second. EPA often uses a unit called a **curie** to

measure activity. One curie is 37 *billion* decays per second. This unit is too large to use at most Superfund sites to assess radiation risk, so EPA usually uses a unit called a **picocurie**. One picocurie is equal to one *trillionth* of a curie, or about 2.2 radionuclide decays per minute.

EPA measures radioactive contamination by the number of picocuries measured in a specific amount of contaminated material. Soil contamination, for example, is measured in picocuries per gram.

Why are radionuclides harmful to human health?

The human body is made up of atoms. When radionuclides decay, they release alpha, beta, and gamma radiation. This radiation can break the bonds between the atoms, damaging living tissue and

DNA. Usually, our bodies can repair this type of damage, but sometimes there may be too much damage to repair. This damage to living tissue and DNA can lead to cancer or other health effects. The risk of cancer increases as exposure to radiation increases.

How can you be exposed to harmful radiation?

Radionuclides cause the most harm when they are inside of the body. There are three ways to be exposed to radionuclides:

- **Inhalation** – Breathing contaminated vapors, dust particles, or radon gas.
- **Ingestion** – Eating contaminated food, drinking contaminated water, or accidentally ingesting small amounts of contaminated dust or soil.
- **External** – Radiation emitting out from a source such as radioactively contaminated soil or object, and then penetrating from outside of the body.

How is radiation exposure measured?

Under most situations, radiation exposure is measured in **dose**. Dose is related to the amount of radiation absorbed by a person's body. The unit for radiation dose that EPA uses is the **millirem**. Millirem relates the absorbed dose of radiation to the amount of biological damage from the radiation.

However, radiation exposure at Superfund sites is measured by **cancer risk**. All radionuclides can cause cancer, and the cancer risk increases as exposure increases. Not all radiation has the same biological effect, even when the absorbed dose is the same, however. Therefore, EPA's use of cancer risk accounts for the different types of radiation as well as its effects on different parts of the body.

How does EPA calculate risks to human health from radiation exposure at Superfund sites?

EPA assesses the health effects of radiation by calculating **excess cancer risk** posed by radioactive contamination. Excess cancer risk is the additional probability that a person exposed to the contamination will develop cancer over a lifetime.

EPA considers excess cancer risk to be any risk above the **protective range**. The protective range is a probability that a person exposed to radioactive and chemical contaminants will have between a one in ten thousand and a one in a million chance of developing cancer, known as the 10^{-4} to 10^{-6} cancer risk range.

It is important to note that, even in the protective range, most people will have less of a chance of developing cancer than these numbers indicate. EPA uses assumptions about exposure levels that are higher than most people's actual exposure.

EPA may also calculate health risk from radiation exposure in dose per year, measured in **millirem per year**. Some regulations at Superfund sites are based on what EPA has calculated to be acceptable dose limits per year.

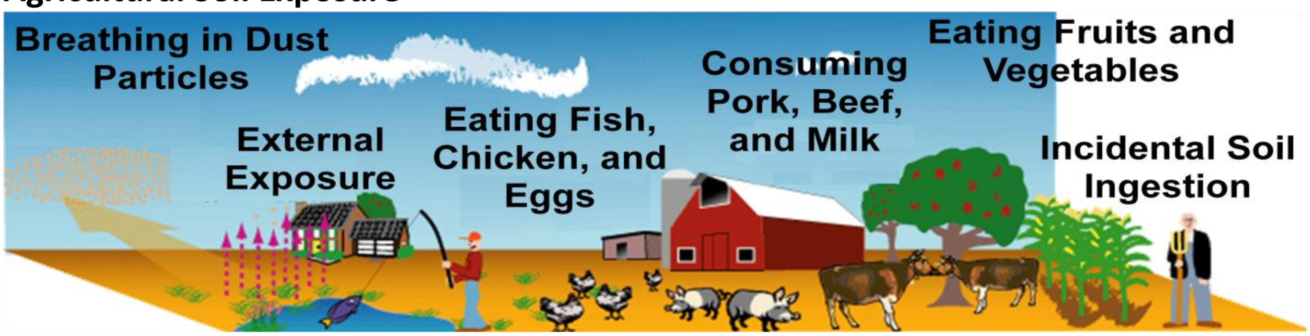
What is background radiation?

Radiation is everywhere in our environment. The average person in the United States receives a radiation exposure of approximately 620 millirems per year from both natural and man-made sources. For examples of radiation in our environment, see the chart "Relative Doses from Radiation Sources" on page 9. These examples include cosmic radiation from space, medical procedures, radiation found naturally in the soil and water, and indoor radon. However, at Superfund sites, EPA is comparing radioactive pollution at the site with background radiation of the same radionuclides where the pollution occurs, such as in the soil and water.

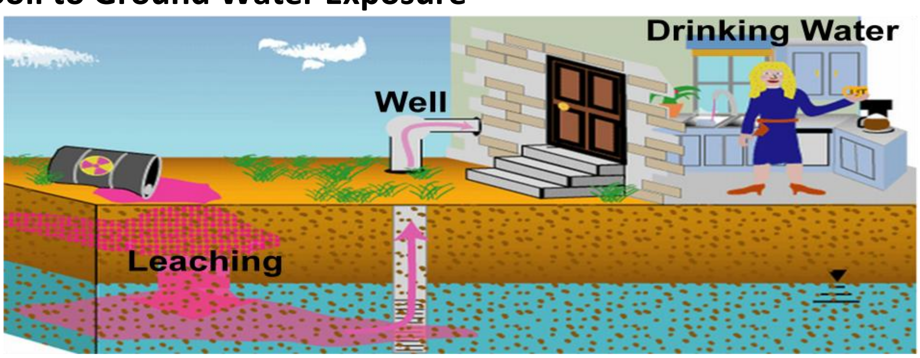
Some Common Ways to be Exposed to Radionuclides at Contaminated Sites

Residential Soil Exposure

Agricultural Soil Exposure



Soil to Ground Water Exposure



Tap Water Exposure

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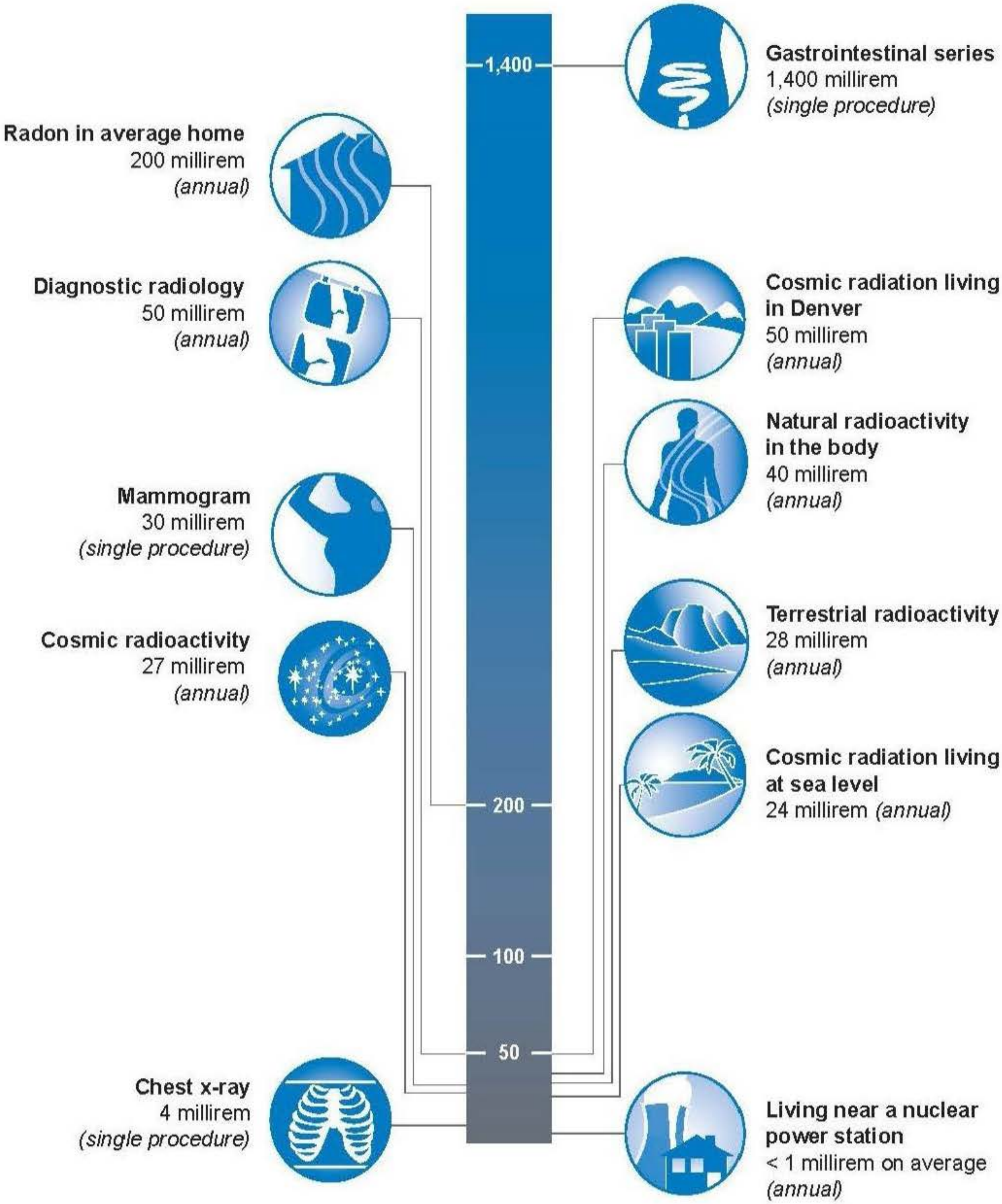
RELATIVE DOSES FROM RADIATION SOURCES
Millirem Doses



What if I want More Information?

If you would like to learn more about EPA's Superfund program, you may want to read the document "This is Superfund: A Community Guide to EPA's Superfund Program," available online at:

http://www.epa.gov/superfund/community/today/pdfs/TIS%20FINAL%209.13.11.pdf

If you have questions about this document, you can contact Stuart Walker of EPA by e-mail at walker.stuart@epa.gov or by telephone at (703) 603-8748.