US Army Corps of Engineers®
Buffalo District

U-238 DECAY CHAIN

This graphic shows the uranium-238 radioactive decay chain. Uranium is a naturally occurring radioactive material present in all soils. It's concentration in project soils was enhanced by the nearby disposal of radioactive Manhattan Engineer District wastes generated during the nations early atomic weapons energy programs.

Radioactive decay involves the spontaneous transformation of one element into another. When the transformation results in a change in the number of protons the product is a different element. An alpha particle consists of two protons and two neutrons. After undergoing alpha decay an atom loses two protons and changes to another element. For example, an atom of uranium (with 92 protons) becomes an atom of thorium (with 90 protons). A beta particle is an electron. After undergoing beta decay, an atom usually gains a proton and changes to another element. For example, an atom of protactinium (with 91 protons) becomes an atom of uranium (with 92 protons).

KEY

α - Alpha Decay
β - Beta Decay
γ - Gamma Decay

Type of Radiation	Radionuclide	Half-life*
α	***uranium-238****	***4.47 billion years***
β	**thorium-234**	**24.1 days**
β	**protactinium-234m**	**1.17 minutes**
α	**uranium-234**	**244,000 years**
α	***thorium-230****	***77,000 years***
α	***radium-226****	***1600 years***
α	**radon-222**	**3.82 days**
α	**polonium-218**	**3.05 minutes**
β	**lead-214**	**26.8 minutes**
β	**bismuth-214**	**19.9 minutes**
α	**polonium-214**	**0.000164 seconds**
β	**lead-210**	**22.3 years**
β	**bismuth-210**	**5.01 days**
α	**polonium-210**	**138.4 days**
	lead-206	**stable**

* The half-life of a radioactive element is the time that it takes for one half of the atoms of that substance to disintegrate into another nuclear form. These can range from mere fractions of a second, to many billions of years. Also, the half-life of a particular radionuclide is unique to that radionuclide. Uranium-238, the most prevalent isotope in uranium ore, has a half-life of about 4.5 billion years; that is, half the radioactive atoms in any sample will decay in that amount of time. Uranium-238 decays by alpha emission into thorium-234, which itself decays by beta emission to protactinium-234, which decays by beta emission to uranium-234, and so on. The various decay products, (referred to as "progeny" or "daughters") form a series starting at uranium-238. After several more alpha and beta decays, the series ends with the stable isotope lead-206.

** Uranium-238, Thorium-230, and Radium-226 are the predominant radioactive contaminents on Formerly Utilized Sites Remedial Action Plan (FUSRAP) sites.

WHAT IS FUSRAP?

The Formerly Utilized Sites Remedial Action Program (FUSRAP) was initiated in 1974 by the United States Department of Energy (DOE) and then transferred, by Congress, to the United States Army Corps of Engineers (Corps) in 1997. Through FUSRAP, the Corps works to ensure that the public and the environment are not exposed to levels of radiation above applicable or relevant and appropriate regulatory standards from these sites. The Corps' goal is to clean up or contain the radioactive material so that these sites may be released for appropriate future land use.

The Nature of Radiation

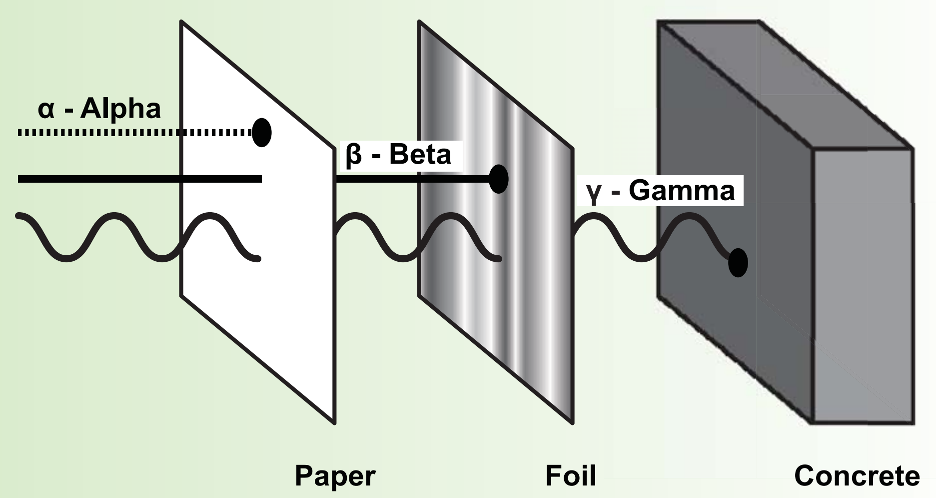
Radiation is a naturally occurring type of energy. It is released by unstable forms of atoms, the basic units of matter, as they change into more stable forms. The energy released is emitted as waves or particles.

α - **Alpha particles** are the largest and slowest atomic particles. They can travel only a few inches through air. They can be stopped by a sheet of paper or the outer layers of skin.

β - **Beta particles** are smaller and faster than alpha particles but can travel only about 10 feet through air. They can easily be stopped by a thin shield such as a sheet of aluminum foil.

γ - **Gamma radiation** consists of gamma rays rather than atomic particles. Gamma rays are a type of electromagnetic wave, much like X rays, and move at the speed of light. They travel farther through air than alpha or beta particles but can be stopped by a thick shield of lead, steel, or concrete.

The penetrating power of the three types of ionizing radiation



- Radiation cannot be seen, heard, smelled, or tasted. However, it can be detected and measured by instruments such as Geiger counters, dosimeters, and similar devices. Levels of radiation are expressed in several different units. One of the most useful is the rem, which measures radiation dose in terms of its potential health effects on persons who might be exposed to It.
- Small amounts of radiation dose are expressed in millirems (thousandths of a rem),abbreviated as mrem. For example, a chest x-ray produces a dose of about 40 mrem, a back x-ray about 3,000 mrem, and a dental x-ray about 150 mrem.
- The amount of radiation that can leave the boundaries of FUSRAP sites is kept to levels as low as reasonably achievable. The exposure a member of the general public can receive as a result of radiation from FUSRAP sites is very low. The maximum allowable exposure is 100 mrem per year above background levels. By comparison, the average American receives about 360 mrem per year from background radiation and medical exposure.

Sources of Radiation

Sources of radiation include geologic formations from the earth, cosmic radiation from outer space, and even some of the foods we eat. For example, a resident of Denver, Colorado, receives about 50 mrem per year from cosmic radiation and another 63 mrem per year from the ground surface. Food accounts for about 20 mrem of our annual radiation exposure. Natural and synthetic substances that emit radiation are called radioactive materials. Many buildings contain naturally occurring radioactive materials. For example, radioactive elements in the granite in the U.S. Capitol Building emit radiation producing an exposure of about 85 mrem per year. The human body itself contains substances that contribute about 11 percent of the average annual radiation exposure. Some consumer products are also sources of radiation. A person who smokes two packs of cigarettes per day receives 8,000 mrem per year. Smoke detectors produce about 1/100 mrem per year. Certain household appliances such as color television sets and microwave ovens also produce very small amounts of radiation. On the average, consumer products account for about 3 percent of our annual exposure.

Radioactive Materials at FUSRAP Sites

During the early years of the nation's atomic energy program, many sites were used by the Manhattan Engineer District (MED) and the Atomic Energy Commission (AEC) [forerunners of the DOE] for processing and storing radioactive materials. Congress later authorized the DOE to clean up the radioactive material at these sites. In October 1997, Congress transferred FUSRAP to the Corps. Several sites with industrial contamination similar to that produced by MED or AEC activities have also been added to FUSRAP by Congress. The radioactive residues at FUSRAP sites consist mostly of elements uranium, thorium, and radium, which emit low levels of radiation.

FUSRAP Radiation Protection

The first step in FUSRAP radiation protection is to determine the levels of radioactivity at the site and background levels in surrounding areas. Air, water, soil, or other routes by which radioactive materials could spread are identified and monitored. At many sites, access restrictions minimize exposure of the public to radioactive materials. Proper storage methods keep contaminants from leaving the site through water or soil. Materials that emit gamma radiation are found in very small amounts at FUSRAP sites and decay more rapidly than materials emitting alpha and beta particles. The radiation produced by gamma-emitting materials decreases over time. FUSRAP provides protection by isolating and shielding them while they decay.