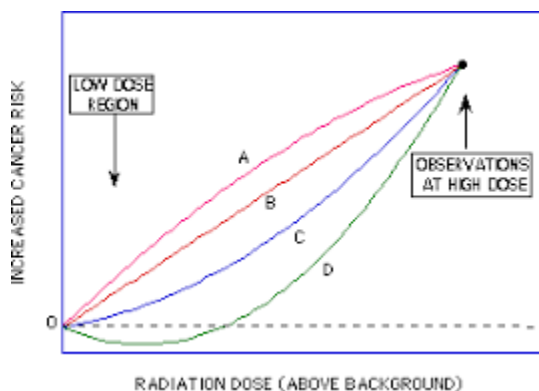


### Hanford Site Cleanup

Nuclear power is thought to be significantly cleaner and more efficient than power sourced by more conventional means such as fossil fuels. Unlike the chemical reactions that fossil fuels undergo, nuclear reactions do not produce harmful greenhouse gasses as a byproduct and are therefore, “emission free”. The power produced in a nuclear reaction is several magnitudes higher than that produced by chemical reactions, so less nuclear fuel is needed. This means that the earth will not be depleted of its natural resources as quickly and there is less damage done to the environment by mining operations. While nuclear power may have a lower impact on the environment than fossil fuels, it is not completely clean. The uranium that serves as fuel in nuclear reactors needs to be mined from the earth using techniques that can leave a large footprint and affect the surrounding environment. There may not be any emissions from the nuclear reaction itself, but the fuel is mined and transported using equipment that runs on fossil fuels. The waste that is produced after the fuel is spent can also be very harmful. If not treated and stored properly, it can have a severe impact on the surrounding ecosystem.

In the year 1943 the US government began construction of the Hanford Site located in southeastern Washington state. The Hanford Site is 586 square miles where several nuclear reactors were built to produce plutonium during World War II. The plutonium was used for the development of nuclear weapons, including the bomb that ended the war (Hanford History). This bomb, or Fat Man as it was code named, contained plutonium-239. Pu-239 can be produced by causing Uranium-235 to fission. The reactors at the Hanford Site were built for this purpose. The workers would fill the reactor with the fuel rods containing U-235 and after a certain amount of time, an optimal amount of U-235 would have decayed into Pu-239 and the workers would replace the fuel rods with new fuel and allow the recently removed ones to cool. The workers were not informed that they were producing fuel for a bomb since it was a highly classified project.

After 44 years of plutonium production and having produced thousands of bombs, the US government decided to organize a project to clean up the Hanford Site. Radiation can have a severe effect on an environment and on animals which we know by studying other areas with



high radiation. In Chernobyl, animals are reported to have cataracts in their eyes and have smaller brains (*At Chernobyl and Fukushima, radioactivity has seriously harmed wildlife*). Radiation can cause genetic defects as well if the ionizing radiation interacts with a reproductive cell. There are multiple models that relate the danger of radiation to the radiation dose. One that is widely accepted is the linear no threshold model. This model (B in the image) suggests that the risk of getting cancer is directly proportional to the radiation dose received. It

is important to clean up places like the Hanford Site in order to protect humans, plants, and animals from suffering the effects of radiation.

Nuclear reactions are not as predictable as chemical reactions. While U-235 can decay into Pu-239, it also transmutes into other isotopes of other elements. There are observable trends that indicate which isotope it will produce but it is not possible to force the mother isotope to produce a specific daughter isotope. For example, a sample of U-235 will alpha decay into

The decay of a radioactive sample does not occur linearly with time but has an exponential trend and is measured by a half-life. The half-life is the amount of time it takes for half of the sample to have decayed. This means that at any given time a sample that was once pure U-235 can be a mixture of U-235, Pu-239, Th-231, Pa-231 and many other isotopes. If a pure sample of one of the daughter nuclides is desired, such as Pu-239, the sample will need to be refined and the desired isotope extracted from the others using various techniques. The isotopes that are not needed for the indicated purpose are discarded or stored as nuclear waste.

When a radioactive isotope decays, it emits various particles and photons that are high in energy and can cause serious damage if they come in contact with an organism. The rate at which the isotope decays is governed by its half-life. The half-life of a radioactive isotope is inversely proportional to its activity, meaning, the shorter the half-life the more radioactive and dangerous it is. Some isotopes are not completely stable, but have an extremely long half-life making them seem stable. These isotopes are not radioactive enough to use in a nuclear reactor but are more than active enough to cause harm. There is not much use for nuclear waste so it must be contained in order to protect the surrounding environment and the population.

There are many misconceptions when it comes to nuclear waste. It is not the slimy, glow-in-the-dark ooze that is stored in pools and can give you super powers if you touch it. The spent nuclear fuel that comes out of the reactor is a solid, but over time can go through phase separations to be solid, liquid, or vapor. “Nuclear fuel is solid when it goes in a reactor and solid when it comes out. It is arranged in fuel assemblies: sets of sealed metal tubes that hold ceramic uranium pellets. The radioactive byproducts of nuclear reactions remain inside the fuel. No green goo anywhere.” (Nuclear Waste). Nuclear waste may not seem so glorious now, but it is still dangerous.

Nuclear waste is most often stored in solid form in tanks and placed underground in an area with a stable climate. The Committee on Remediation of Buried and Tank Wastes describes a problem with this method. “A basic problem with the tank wastes at the Hanford Reservation is that leakage into the underlying soils has already occurred in the 200E and 200W operating areas.” (Committee on Remediation of Buried and Tank Wastes 5). If the tanks are exposed to the environment, they can fail and the waste can leak as it already has on the Hanford Site. When the waste leaks, it may not have an immediate effect on the surrounding area but eventually it can be dissolved in ground water and flow towards major rivers like the Columbia River. The Columbia River is less than 100 miles from the Hanford Site. Once the nuclear waste reaches a river it can be carried far downstream and have an effect on the environment with a much larger radius. One solution is to install barriers in the ground that can clean the ground water as it passes through. Another solution is to pump the ground water out of the ground, chemically treat it, then pump it back into the ground. The Hanford Site is implementing both of these techniques (7).

It is also possible to vitrify the waste. Vitrification "...converts liquid radioactive and

Mixed toxic wastes inside a tank; vapors rise to the top, creating pressure.



chemical waste into a solid, stable glass, eliminating environmental risks.” (What is Vitrification). Vitrification is a well-established process and the Hanford Site had a plan to employ this process. Vitrification was not implemented entirely when the clean-up project began because “...the methodology of that process was not fully established when construction began, and many difficulties have arisen”. The difficulties preventing vitrification of the waste at the Hanford Site is partially due to the amount of time that the waste had been allowed to sit. Much of it has separated into different phases and the waste in different phases needs to be treated accordingly. (Hanford Site Nuclear Waste Cleanup Site Facing Troubles). The Hanford Site still has plans to vitrify the remaining waste and will be an excellent solution because glass is much more stable than liquid and will not dissolve into the ground water (Hanford Cleanup). The solid waste can also be vitrified by dissolving it in an aqueous

solution and then vitrifying the solution.

It is projected that the Hanford Site cleanup will continue past the year 2090 because the spent nuclear fuel is not the only waste that the Hanford Site needs to dispose of (Burger et al.). Buildings, clothes, and surrounding dirt were contaminated with radioactive material so they need to be treated like nuclear waste. There was also a lot of chemical waste from the different methods of extracting the Pu-239 that are very dangerous to the environment and population health. The buildings were also built with materials like asbestos so they need to be destroyed and discarded.

When cleaning up a place like the Hanford Site, it is critical that the cleanup crews take the necessary precautions to protect themselves and the environment that they are trying to clean. If the cleanup process is not done correctly and safely, then it will be in vain because the environment and the people will be exposed. In 2003 the Government Accountability Project or GAP, released a report explaining that over a two-year period there was a dramatic increase of workers at the Hanford Site needing medical treatment because of exposure to chemical vapors (Carpenter et al.). Apparently, the increase in medical incidences was due to the workers being pushed by management to offer a faster and cheaper cleanup. By attempting to cut corners, the workers were exposed to the very substances that they were trying to protect others from. Before the Hanford cleanup project began, safety measures were put in place but those measures often compete with deadlines that cause the workers to ignore the rules for the sake of getting something done on time.

Critics may say that the Hanford Site cleanup project is a waste of resources because it is in the middle of a desert so it won't affect anybody. I argue that it is critical to the upkeep and stability of the planet and its ecosystems. Nuclear power is not entirely clean. If nuclear waste is released into the environment, it may not affect the human population immediately. Over time however, it will cause damage to the fish, birds, and other wildlife that we depend on for nourishment. It can change the nuclear composition of the rivers and oceans causing the water to have a different effect in our bodies. In order to maintain the safety of the human population, the Hanford Site, along with other nuclear and chemical plant sites, should be cleaned properly.

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