NUCLEAR RADIATION and RADIOLOGICAL FALLOUT

The Waldo Civil Defense Association

With Information from the

The American Civil Defense Association (TACDA),

FEMA and US CDC

What is Radiation?

- The energy that comes out of a radioactive atom.
- 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.

What is Radioactivity?

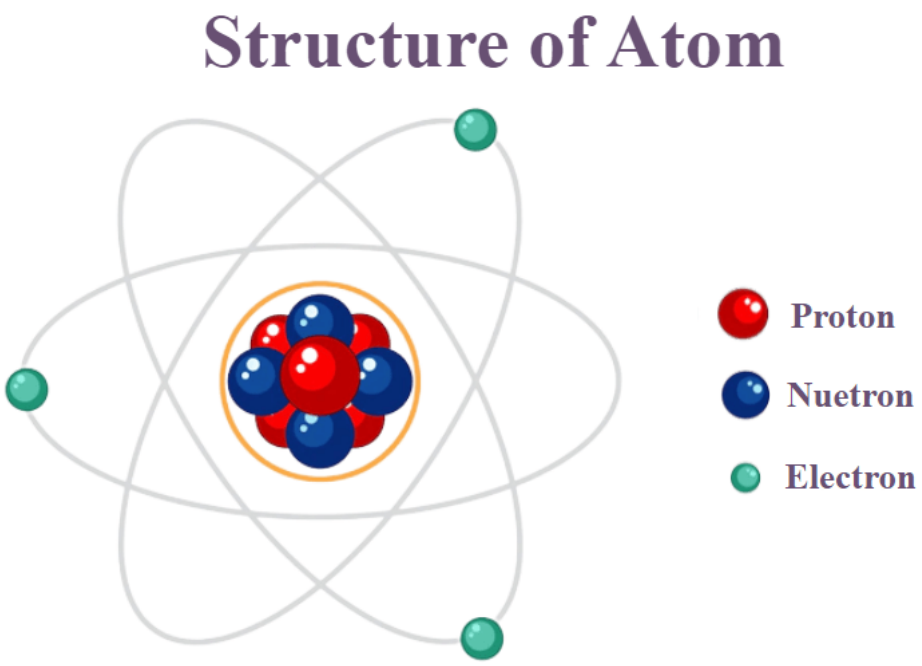
- The spontaneous release of energy from an unstable atom.
- The process of spontaneous transformation of the nucleus, generally with the emission of alpha or beta particles often accompanied by gamma rays. This process is referred to as decay or disintegration of an atom.

Radiation Definitions

- **Radioactive material** is a solid, liquid, or gas that gives off radiation.
- **Radioactive isotopes** are radioactive atoms of the same element that have different numbers of neutrons.

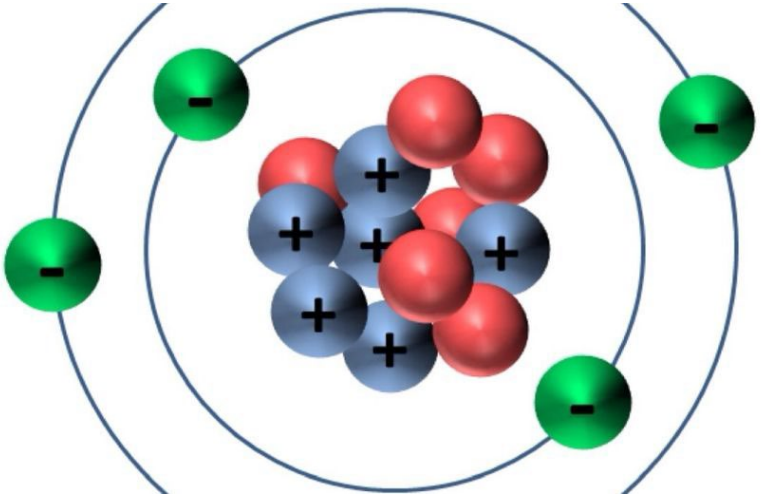
What is the Atom?

- Atoms are the building blocks of matter. Their structure determines their elemental and chemical properties.
- Atoms are composed of a nucleus, containing protons and neutrons, surrounded by a cloud of electrons.



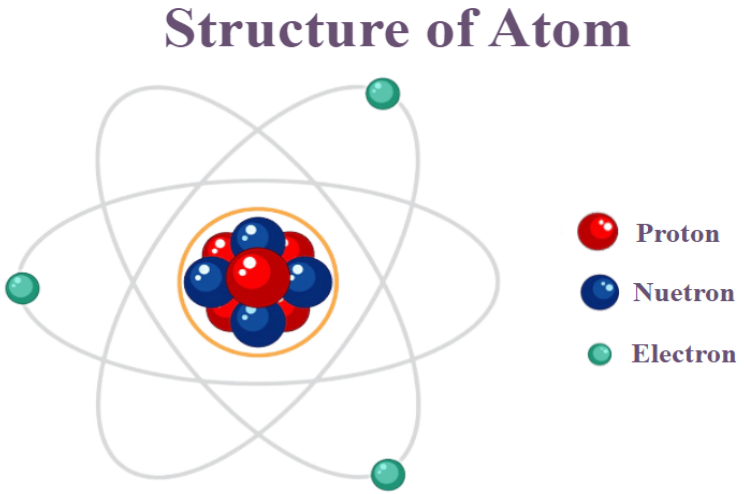
What is the Atom?

- The number of protons in the nucleus determines the identity of the atom (chemical element).
- For example, a carbon atom has 6 protons. If you were able to add another proton to the carbon nucleus, you wouldn't have a carbon atom anymore: you'd have a nitrogen atom instead.



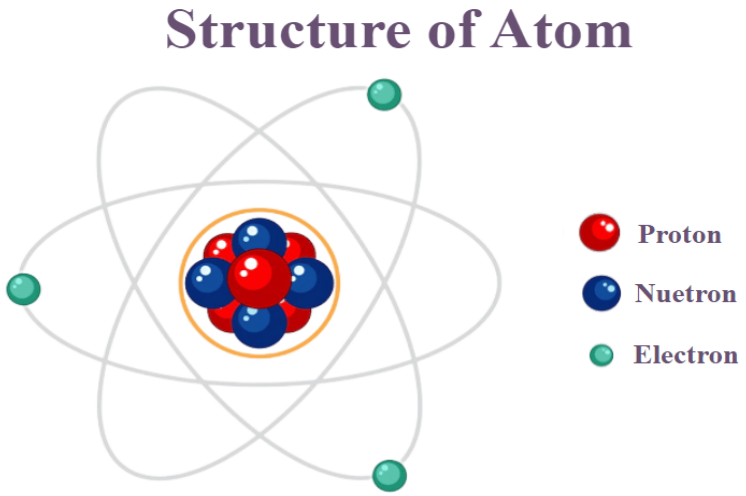
What is the Proton?

- A small atomic particle, typically found within an atom's nucleus, that possesses a positive electrical charge. Even though protons and neutrons are about 2,000 times heavier than electrons, they are tiny. The number of protons is unique for each chemical element.



What is the Neutron?

- A small atomic particle possessing no electrical charge typically found within an atom's nucleus. Neutrons are, as the name implies, neutral in their charge. That is, they have neither a positive nor a negative charge. A neutron has about the same mass as a proton.

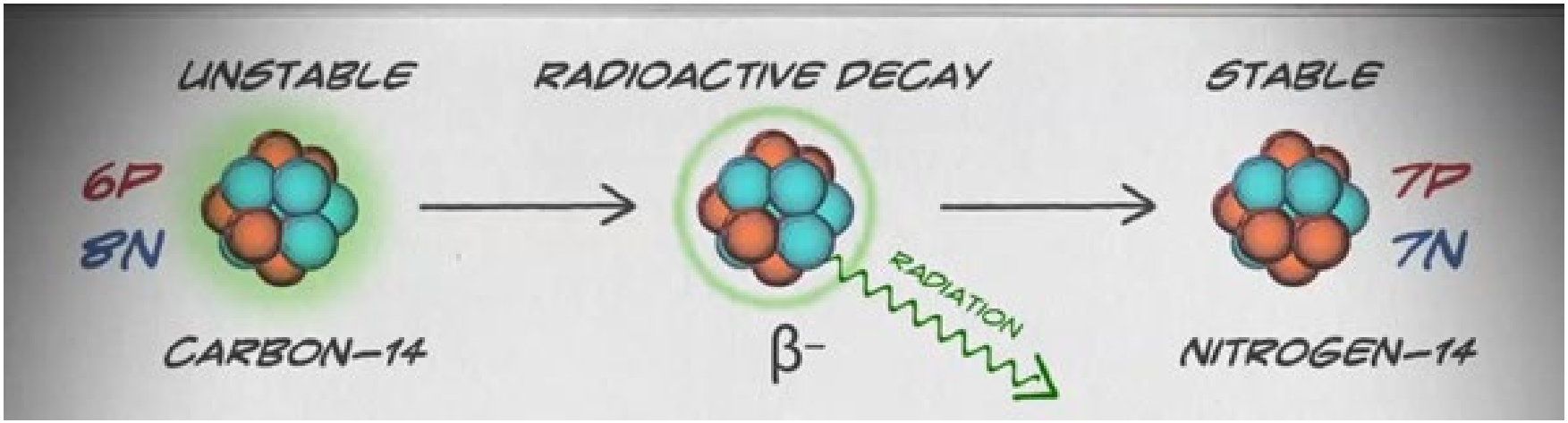


What is the Electron?

- An elementary particle with a negative electrical charge and a mass 1/1837 that of the proton. Electrons surround the nucleus of an atom because of the attraction between their negative charge and the positive charge of the nucleus. A stable atom will have as many electrons as it has protons. The number of electrons that orbit an atom determine its chemical properties.

Radiation Decay

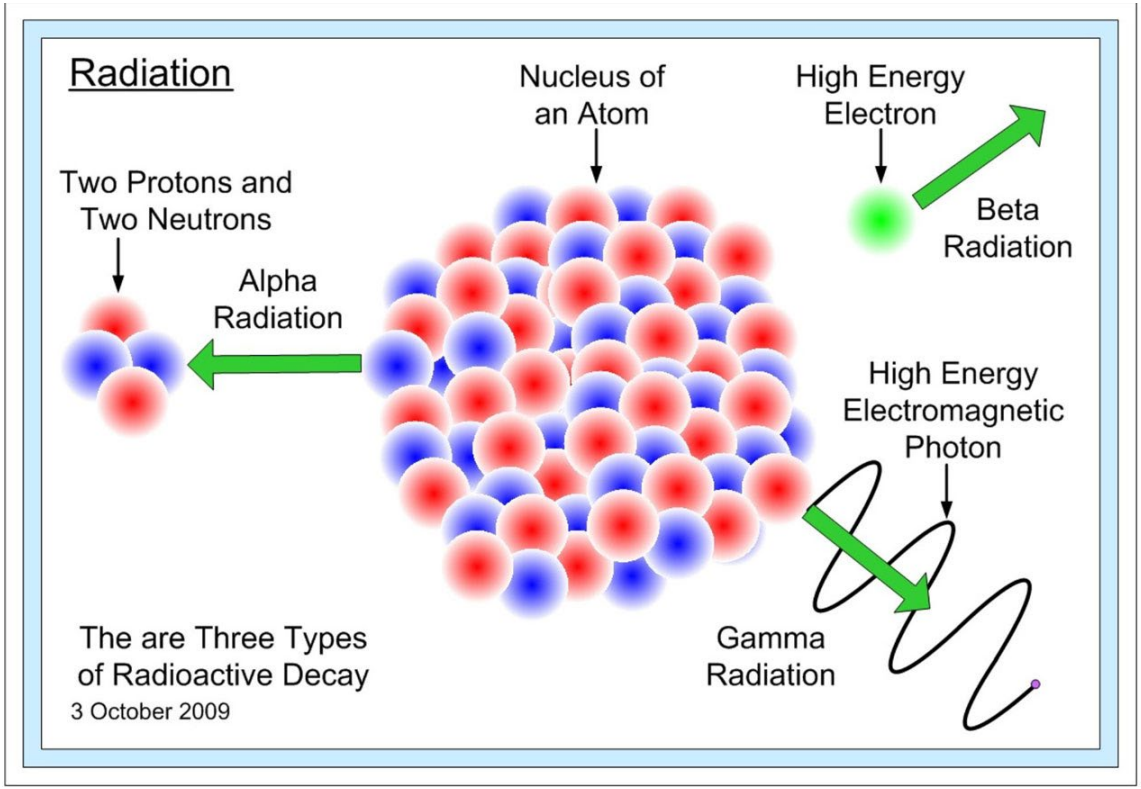
- The change from an unstable atom to a more stable atom by the emission of radiation.
- Disintegration of the nucleus of an unstable atom by the release of radiation



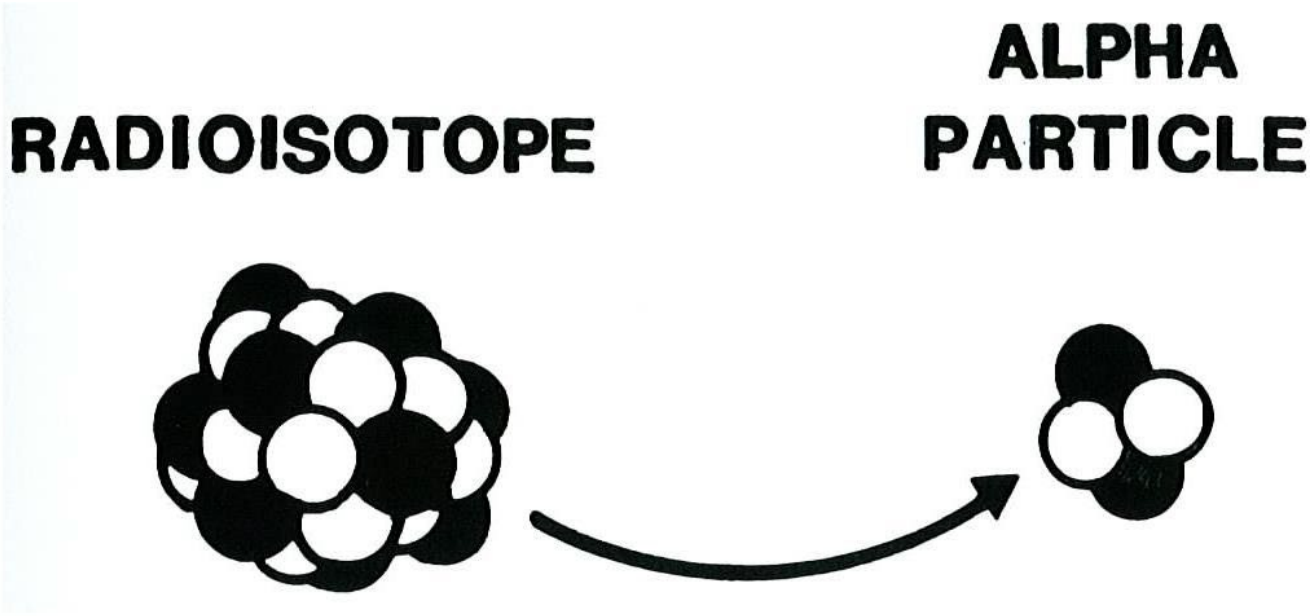
What are the types of Radiation?

- Alpha Particles
- Beta Particles
- Gamma Rays

- Neutrons



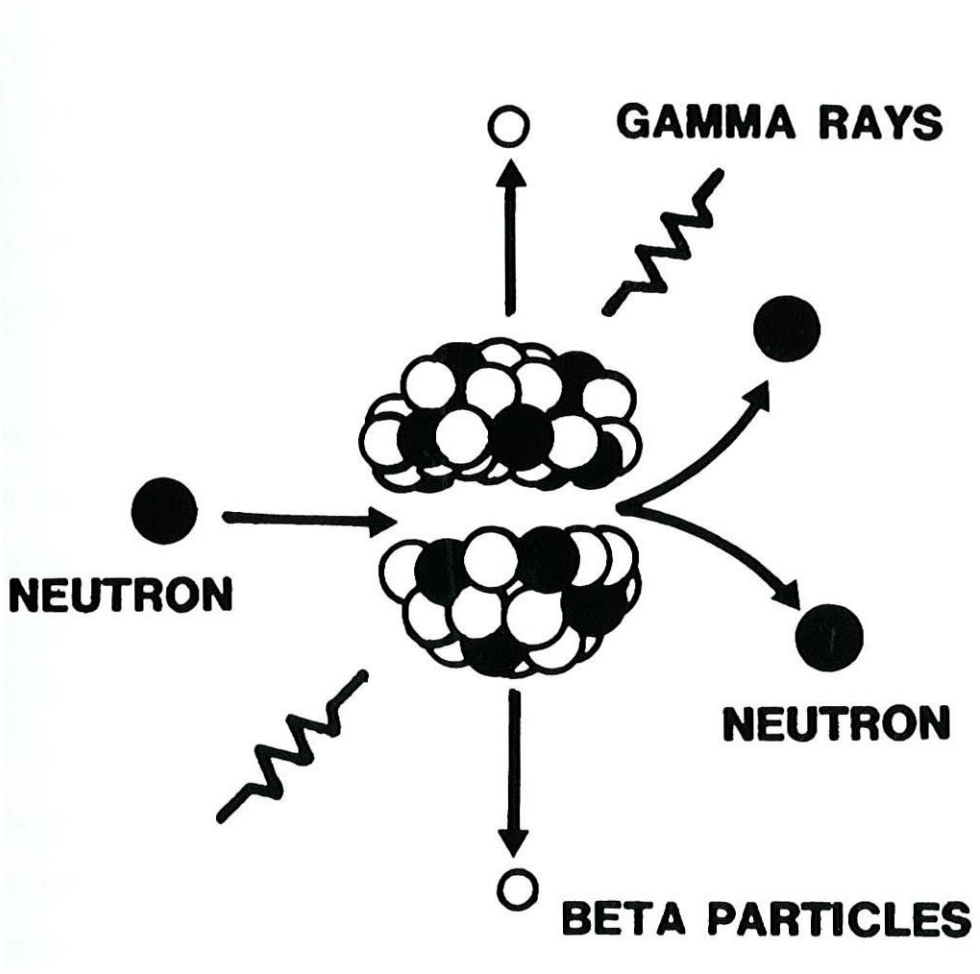
ALPHA PARTICLE
(Two Protons & Two Neutrons)



What is an Alpha Particle?

- Large particles that travel up to an inch in the air.
- Very easy to block, even with something as thin as a sheet of paper.
- Do not present an external hazard to people because they can’t get through our outer layer of dead skin cells.
- However, they can be very damaging to cells inside our bodies if we breathe or eat alpha-emitting radioactive material or if the radioactive material is introduced through an open wound.

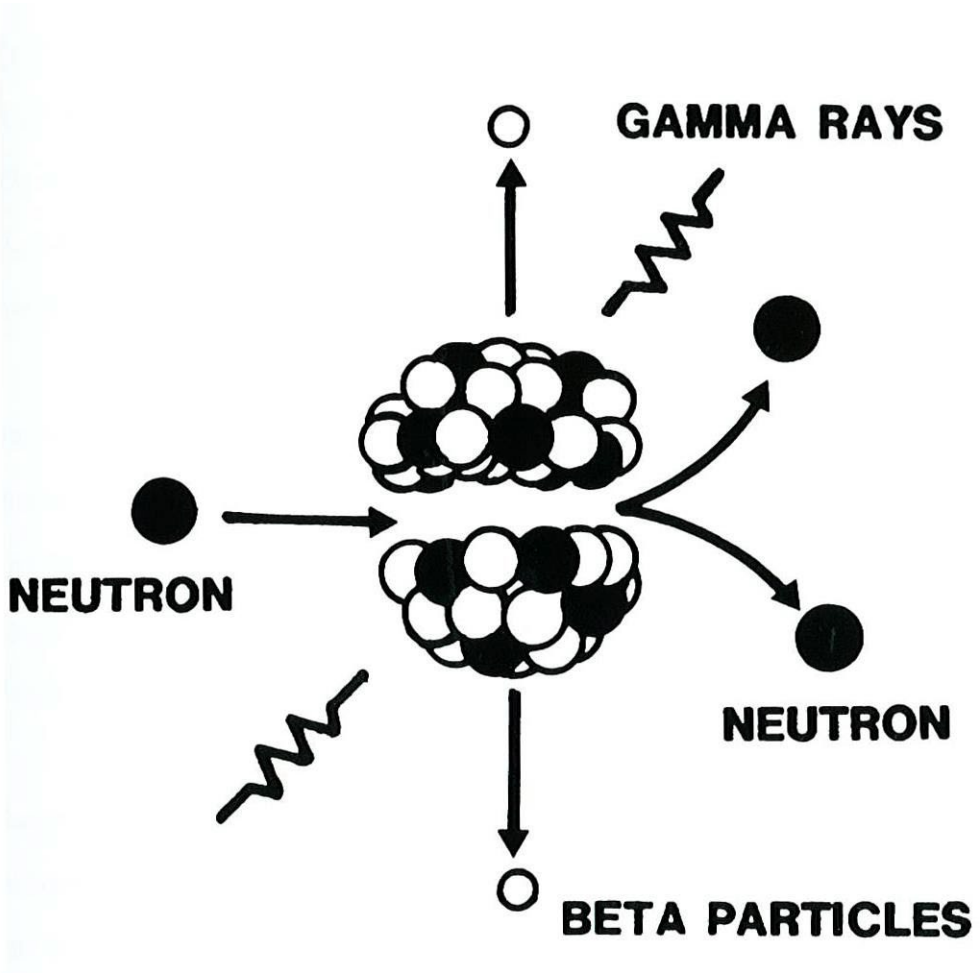
BETA PARTICLES



What is a Beta Particle?

- Smaller particles that travel several feet in air.
- Can be blocked effectively with a few inches of plastic, or even a layer of clothing.
- However, they carry enough energy to cause burns on exposed skin and present an internal hazard if we breathe or eat beta-emitting radioactive material or if the radioactive material is introduced through an open wound.

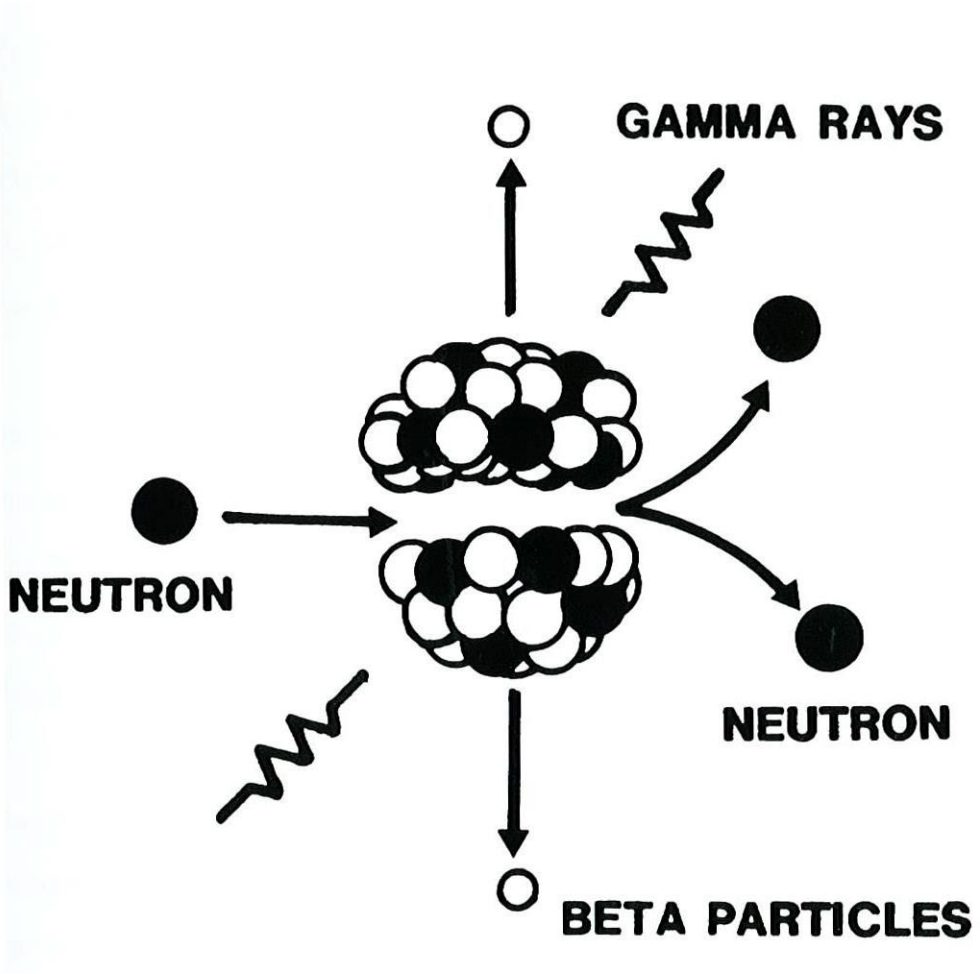
GAMMA RAYS



What is a Gamma Ray?

- Can travel many yards in air.
- Primarily an external hazard because of their ability to go through material.
- It takes a few inches of lead or other dense substance to block gamma rays.

NEUTRONS

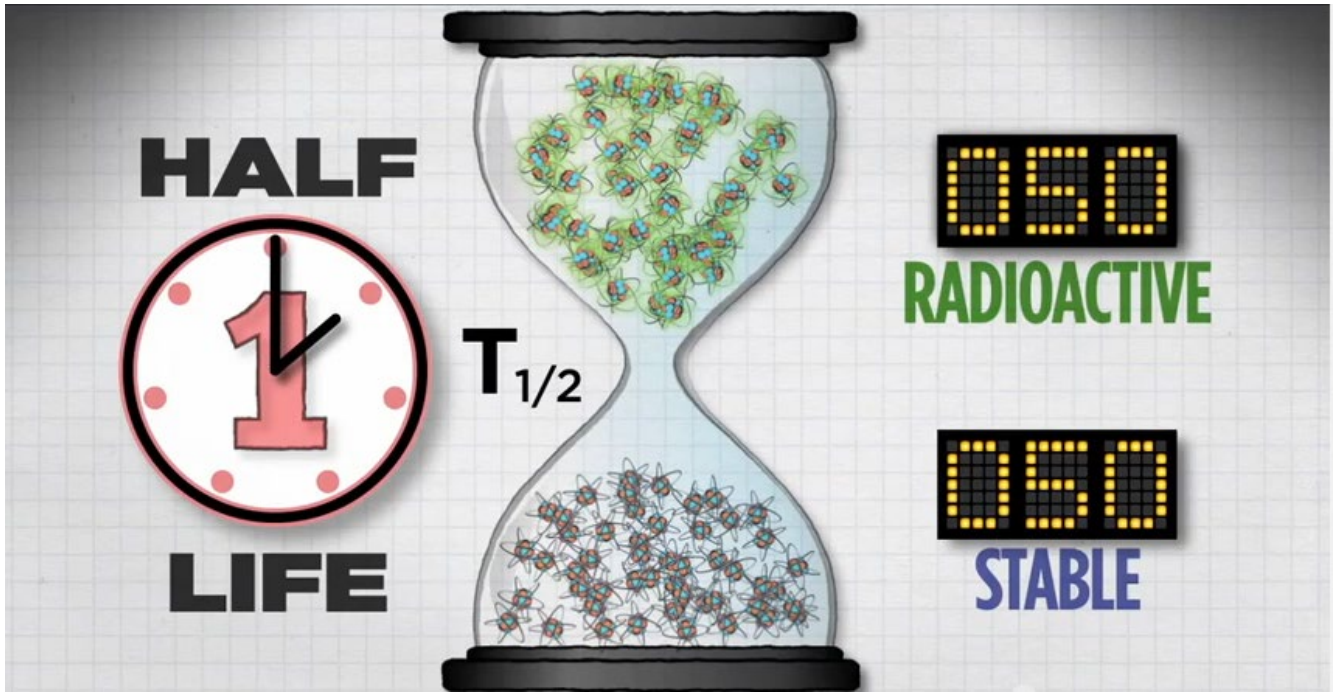


What is a Neutron?

- Neutral particles with no electrical charge that can travel great distances in the air.
- As neutrons travel through matter, they crash with atoms. These atoms can become radioactive.
- More effective at damaging cells of the body than are other forms of ionizing radiation, such as x-rays or gamma rays.
- Not present in Fallout. Initial radiation from a nuclear explosion; within a few miles.

What is Half Life?

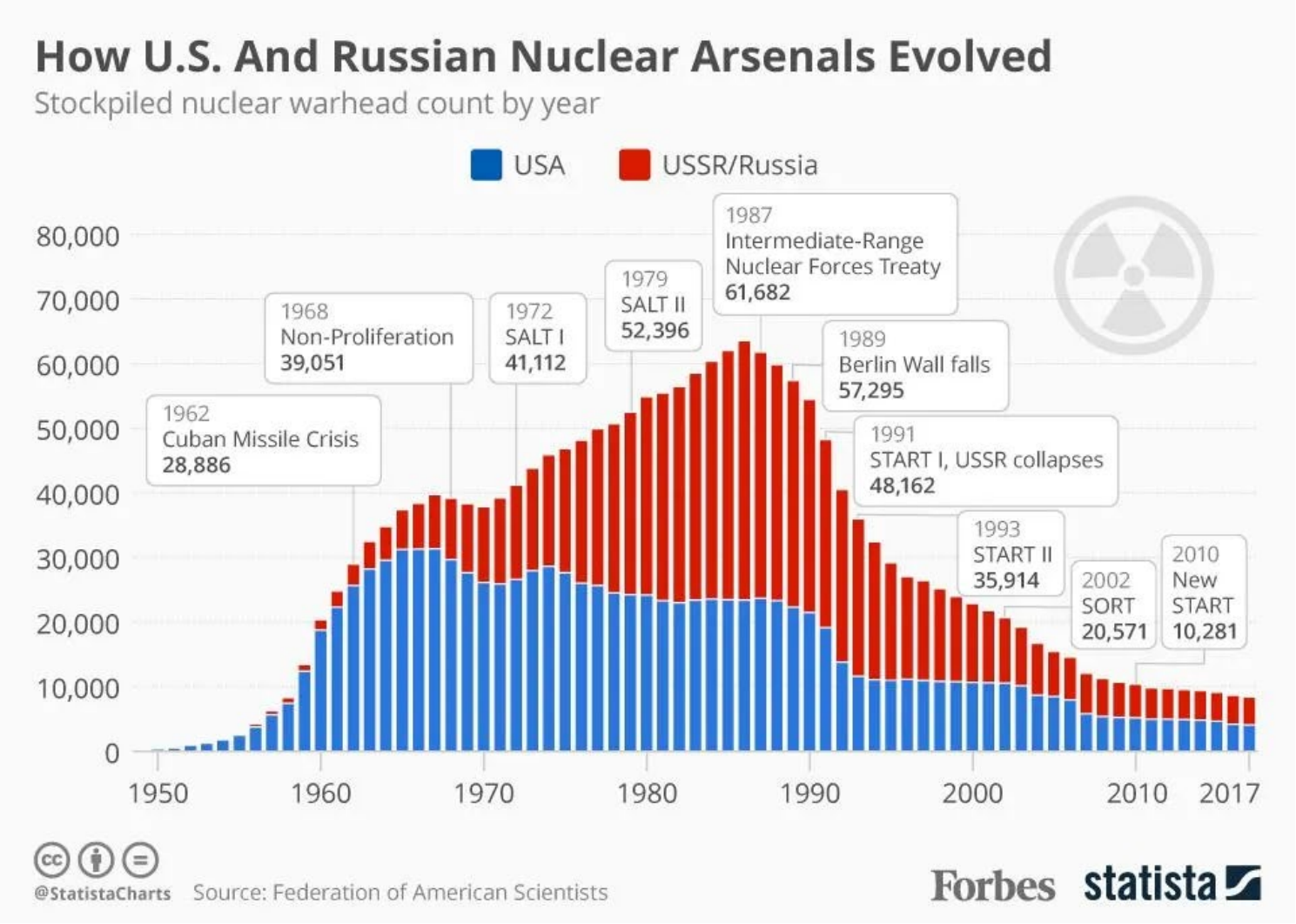
- Half-life is the length of time it takes for half of the radioactive atoms of a specific radionuclide to decay.



Measuring Radioactivity

	SI unit	Conventional unit
Radioactivity	Becquerel (Bq)	Curie (Ci)
	1 Bq = 1 disintegration per second 1 Ci = 3.7×10^{10} disintegrations per second = 37 GBq	
Absorbed dose	Gray (Gy)	rad
	1 Gy = 1 J/kg = 100 rad	
Effective dose	Sievert (Sv)	rem
	1 Sv = 100 rem	
Linear energy transfer	Newton (N)	keV/μm
	1 N = 1 J/m 1 keV/μm = 1.6×10^{-13} N	

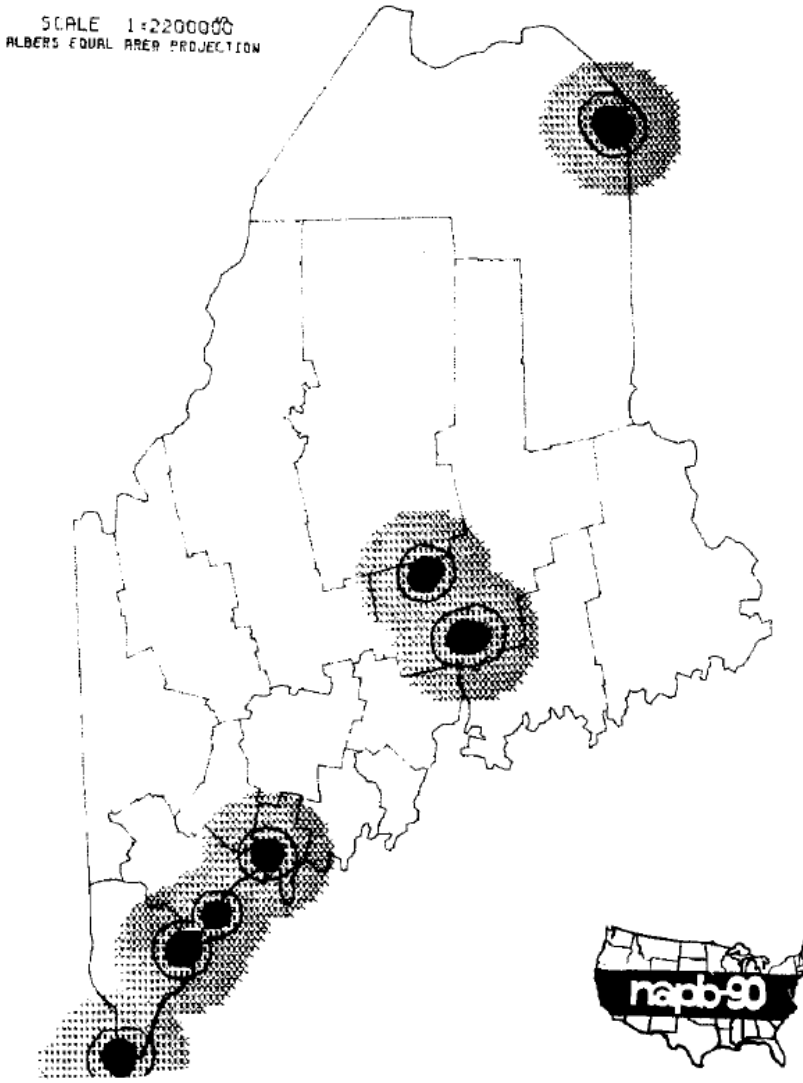
What is the Nuclear Threat?



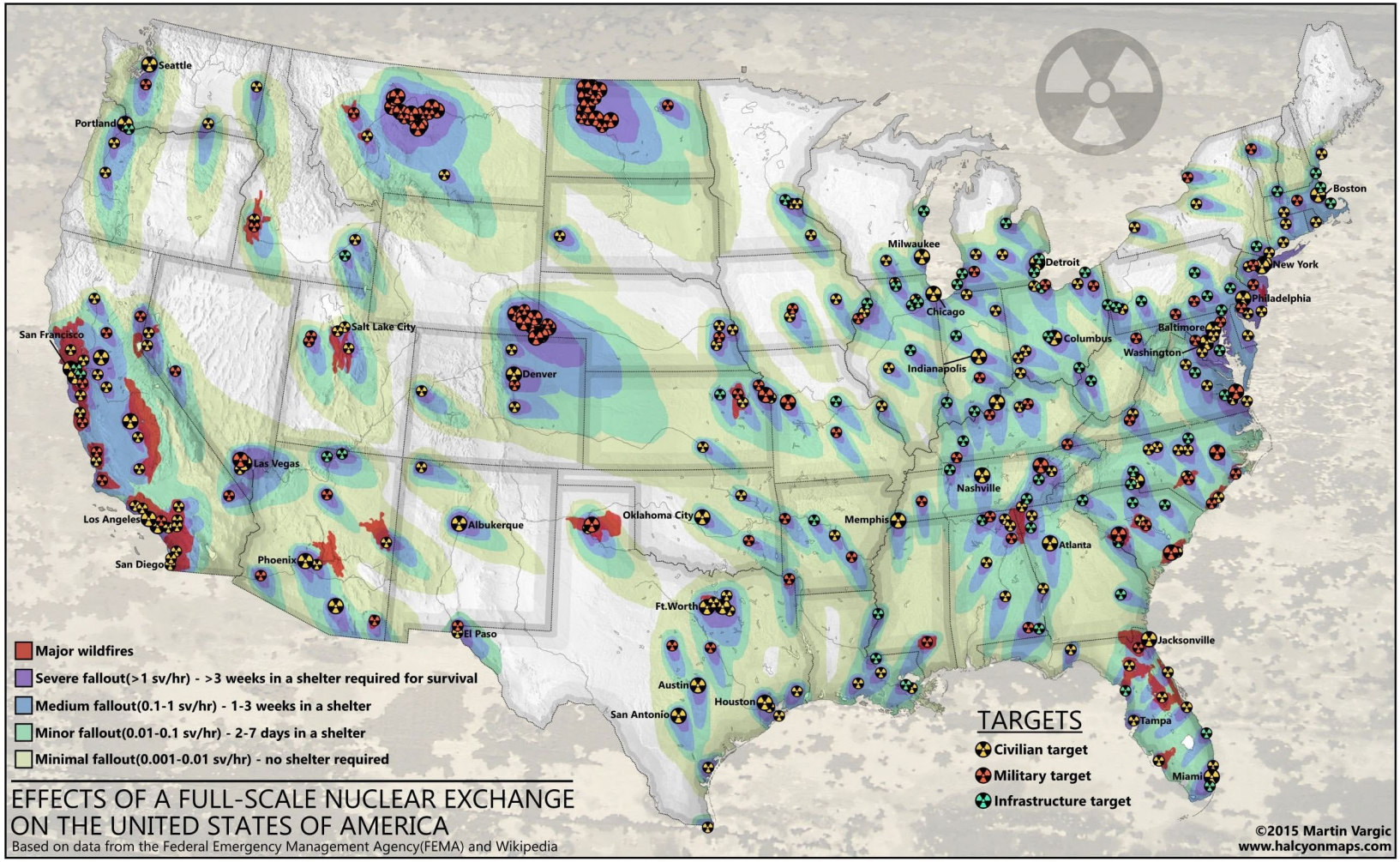
What is the Nuclear Threat?

Maine Nuclear Targets

- All out Nuclear Attack
  - Kittery Naval Shipyard
  - Bangor Air National Guard
  - Probably smaller nukes
- Limited Exchange
  - No targets in Maine

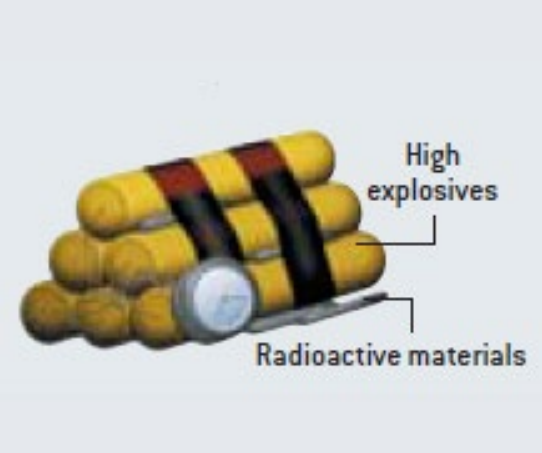


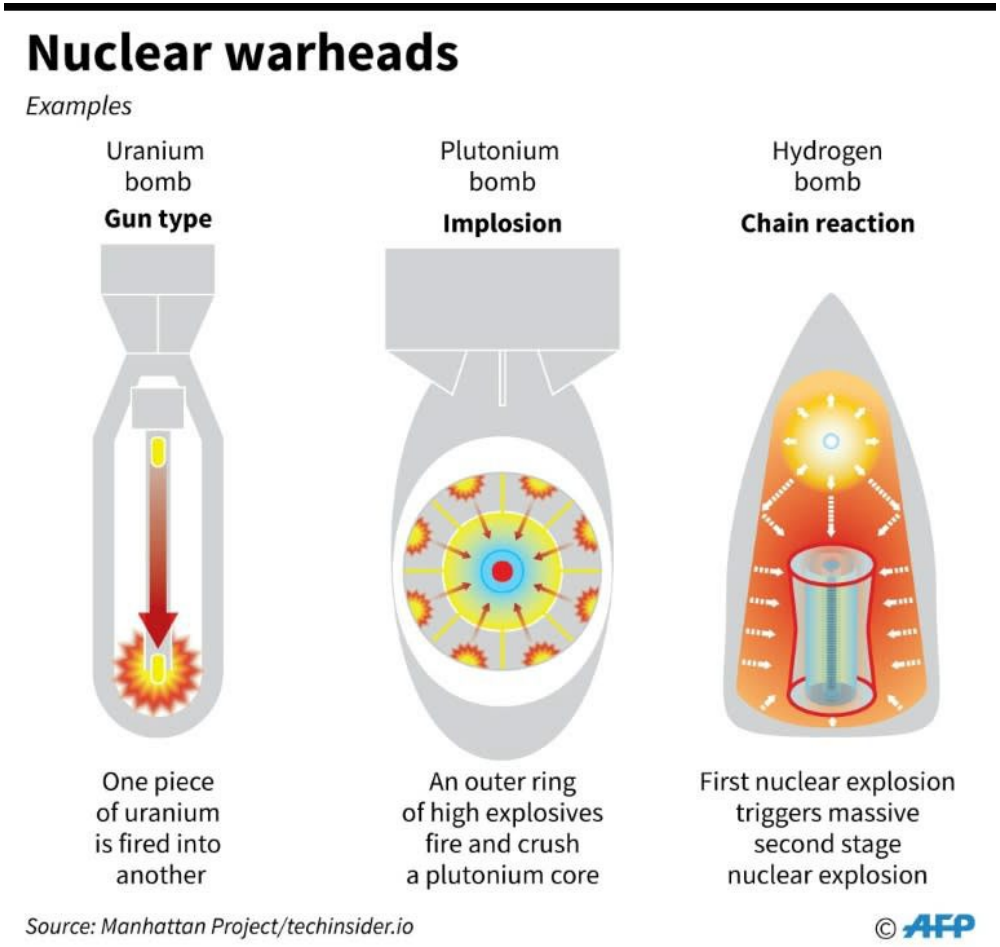
US Nuclear Targets



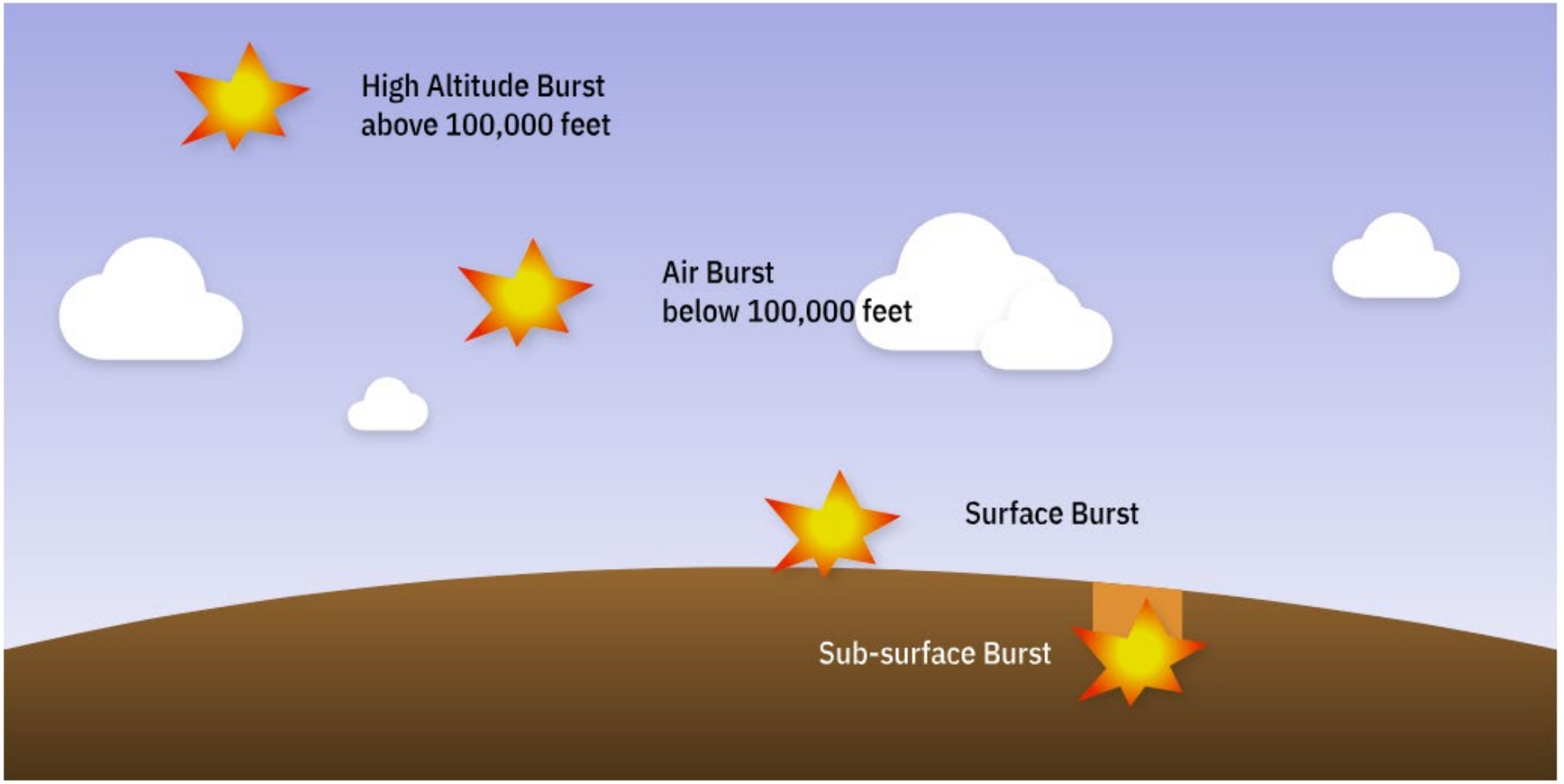
Types of Nuclear Weapons

- Fission Bombs
- Fusion Bombs
- Dirty Bombs





Types of Nuclear Bursts



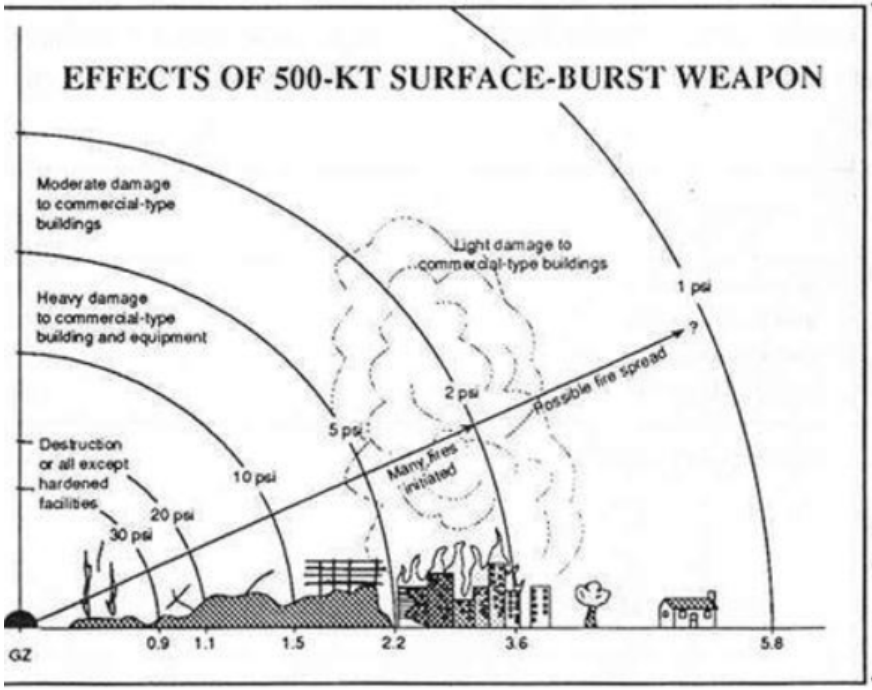
What are the effects?

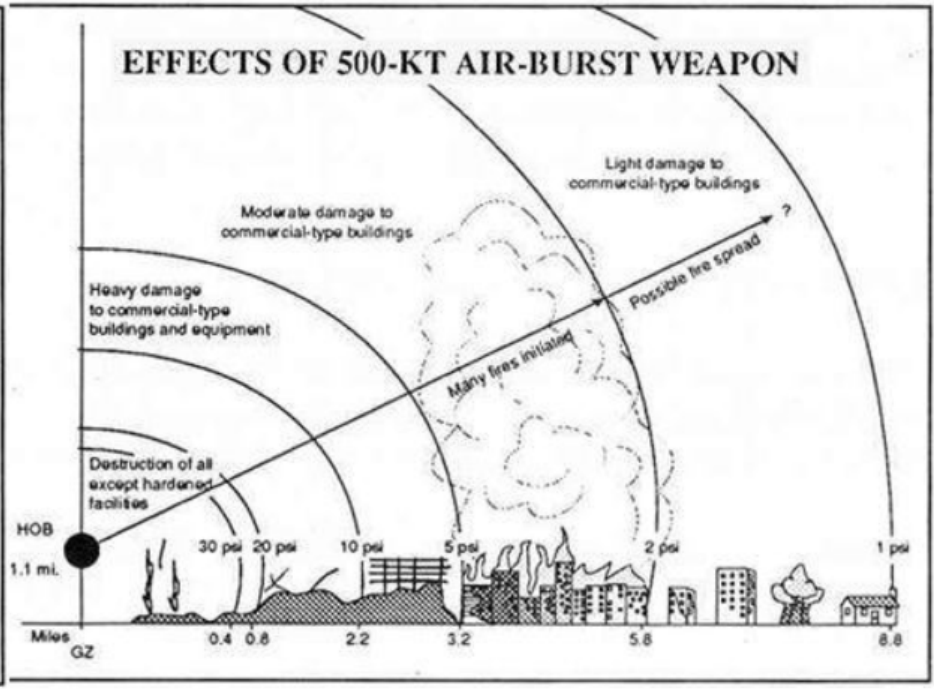
- Thermal (Fireball)
- Blast (Cratering & Overpressure)
- Radiation
  - Initial (Neutron)
  - Fallout (Alpha, Beta, Gamma)
- Electromagnetic Pulse (EMP)

What are the effects?

- Depends on type

Surface burst versus airburst

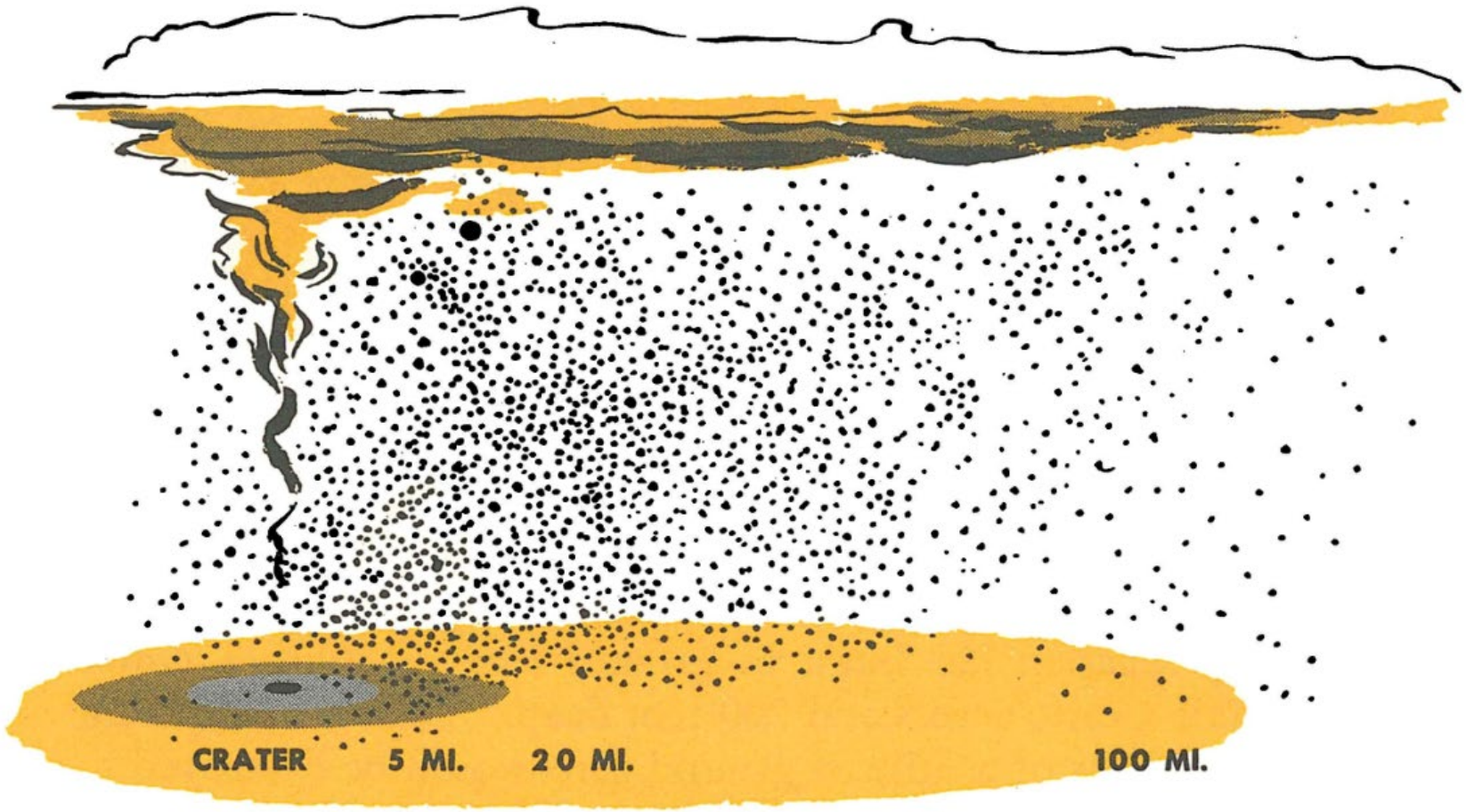




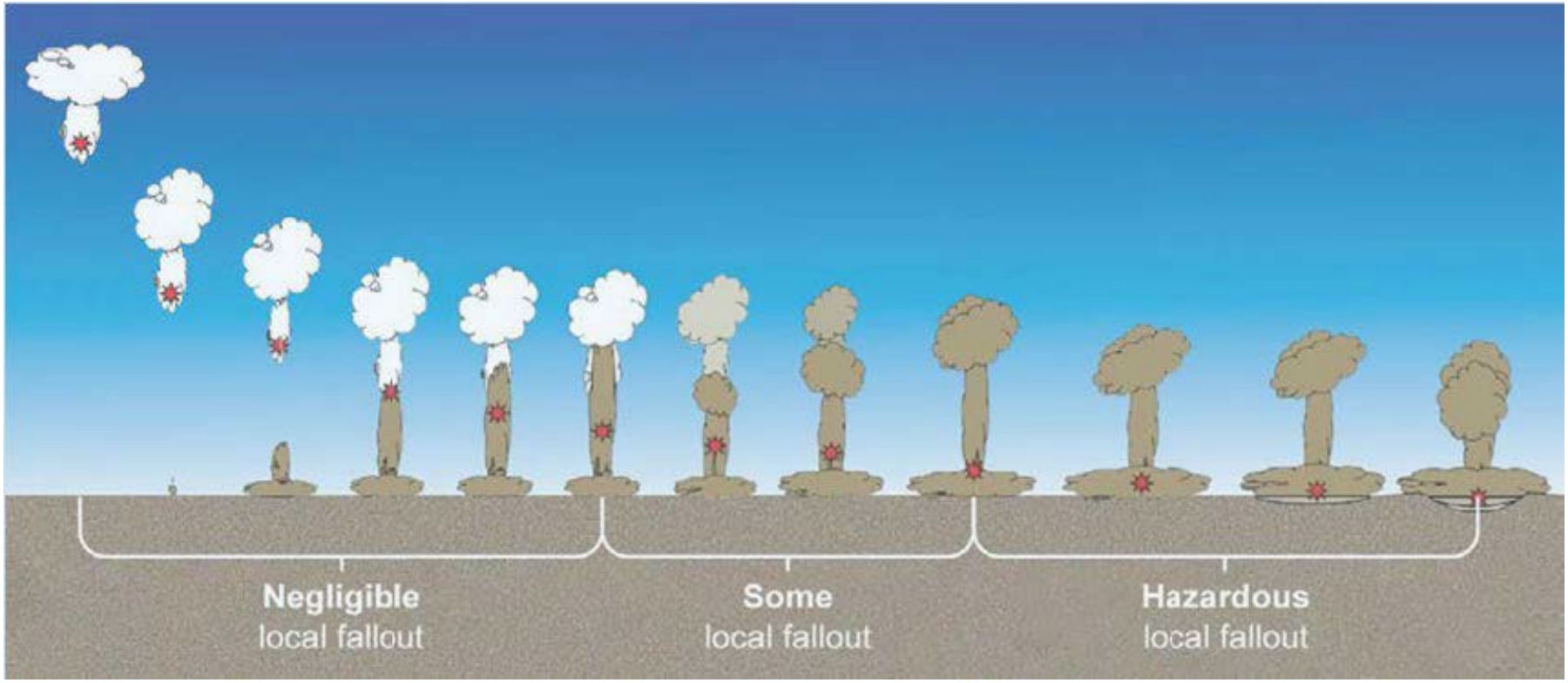
What is Nuclear Fallout?

- If the fireball of the weapon touches the ground, the blast is defined as a ground burst. In a ground burst, rock, soil, and other material in the area will be vaporized and taken up into the cloud. Strong winds cause dust, dirt, and other particles to be sucked up into the fireball as well. All of this debris is then mingled with fission products and radioactive residues and becomes radioactive itself. As it cools, the debris falls from the cloud onto the ground. This material is what we call radioactive fallout.

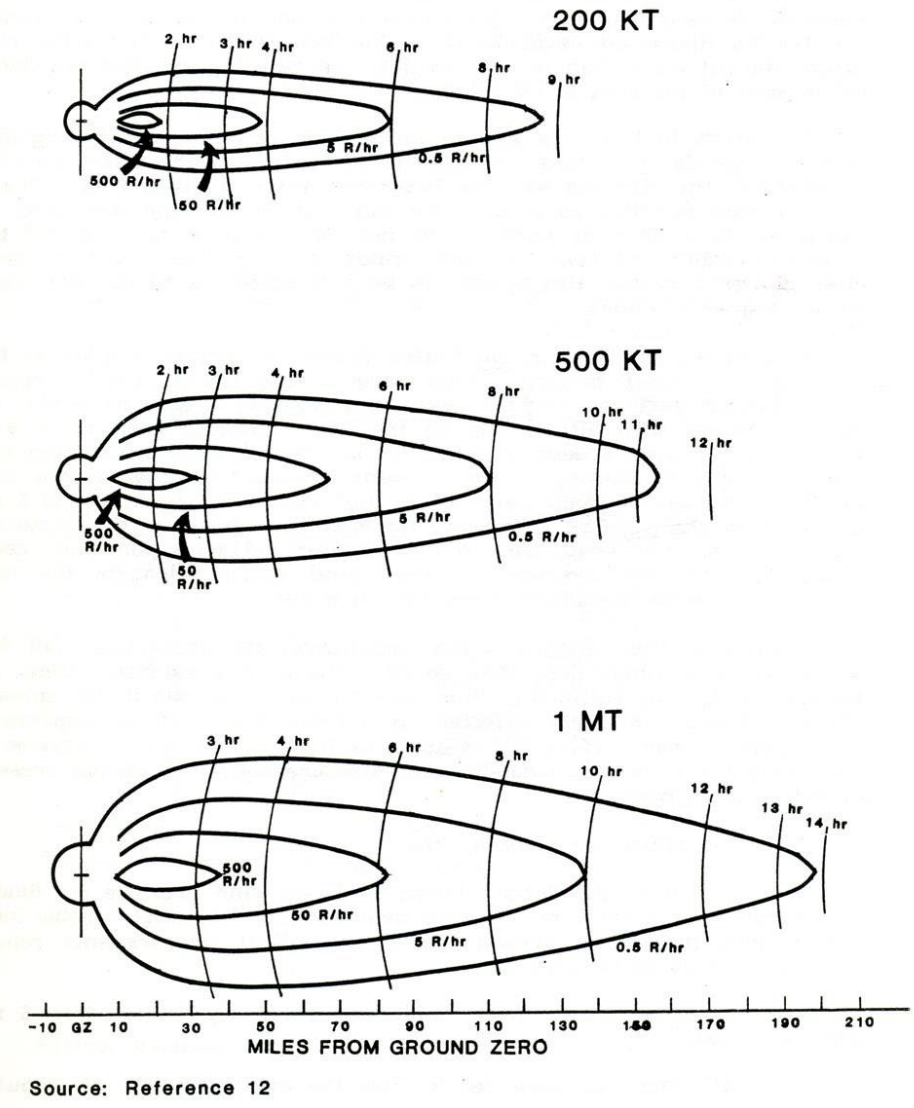
What is Nuclear Fallout?



Fallout from types of bursts



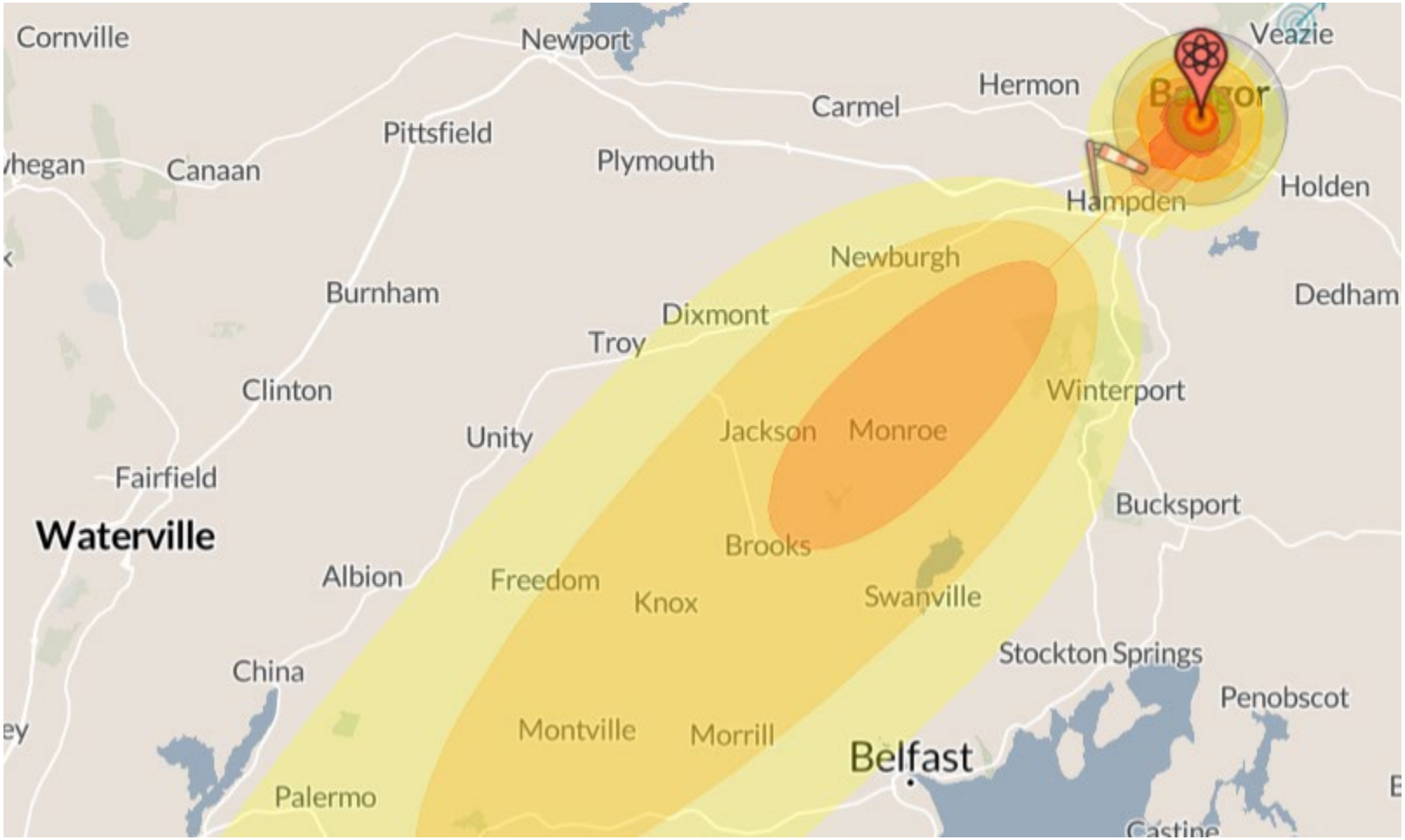
FALLOUT PATTERNS



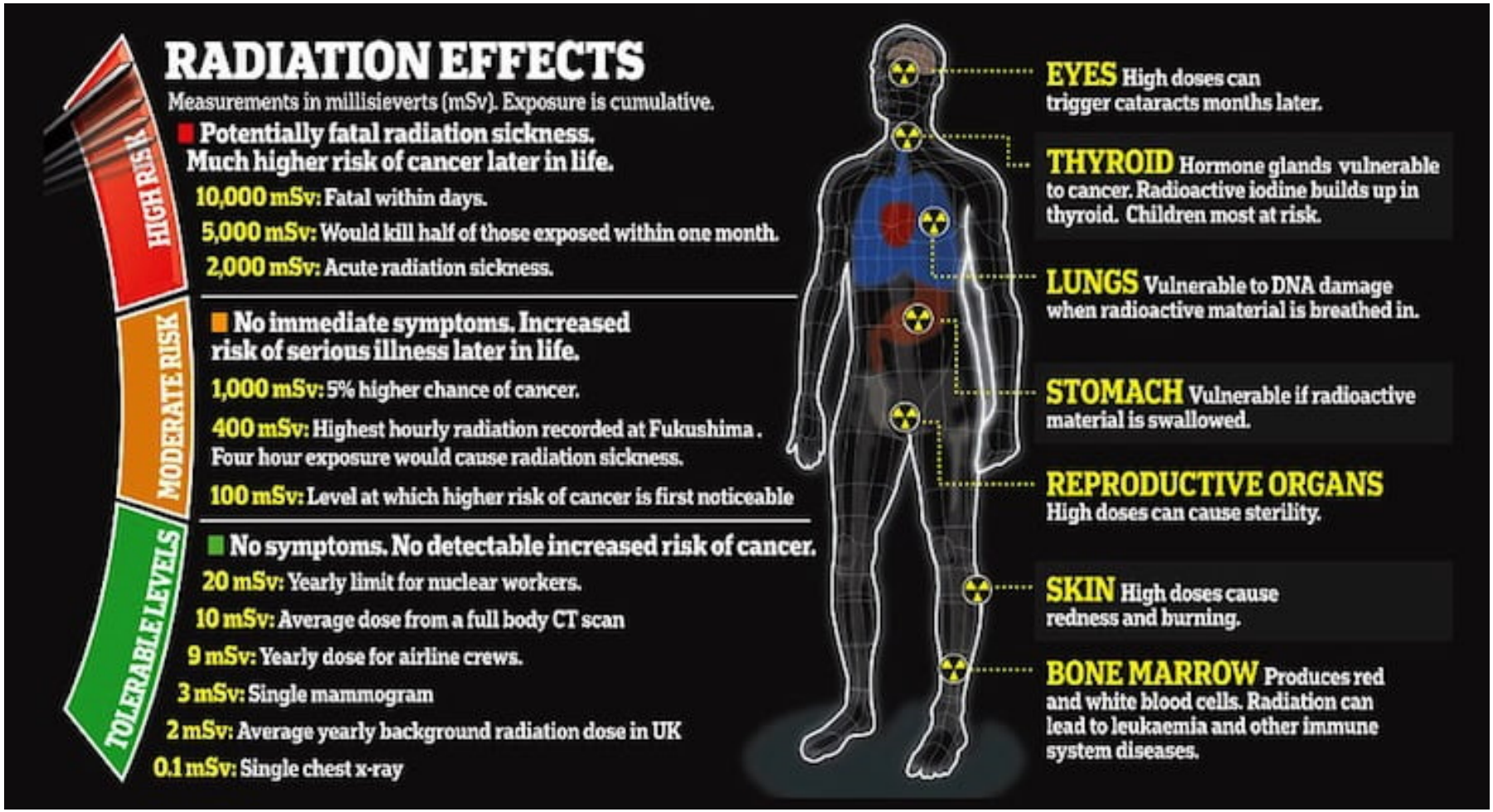
Source: Reference 12

Nuclear Plotting

- Visit: https://nuclearsecrecy.com/nukemap/

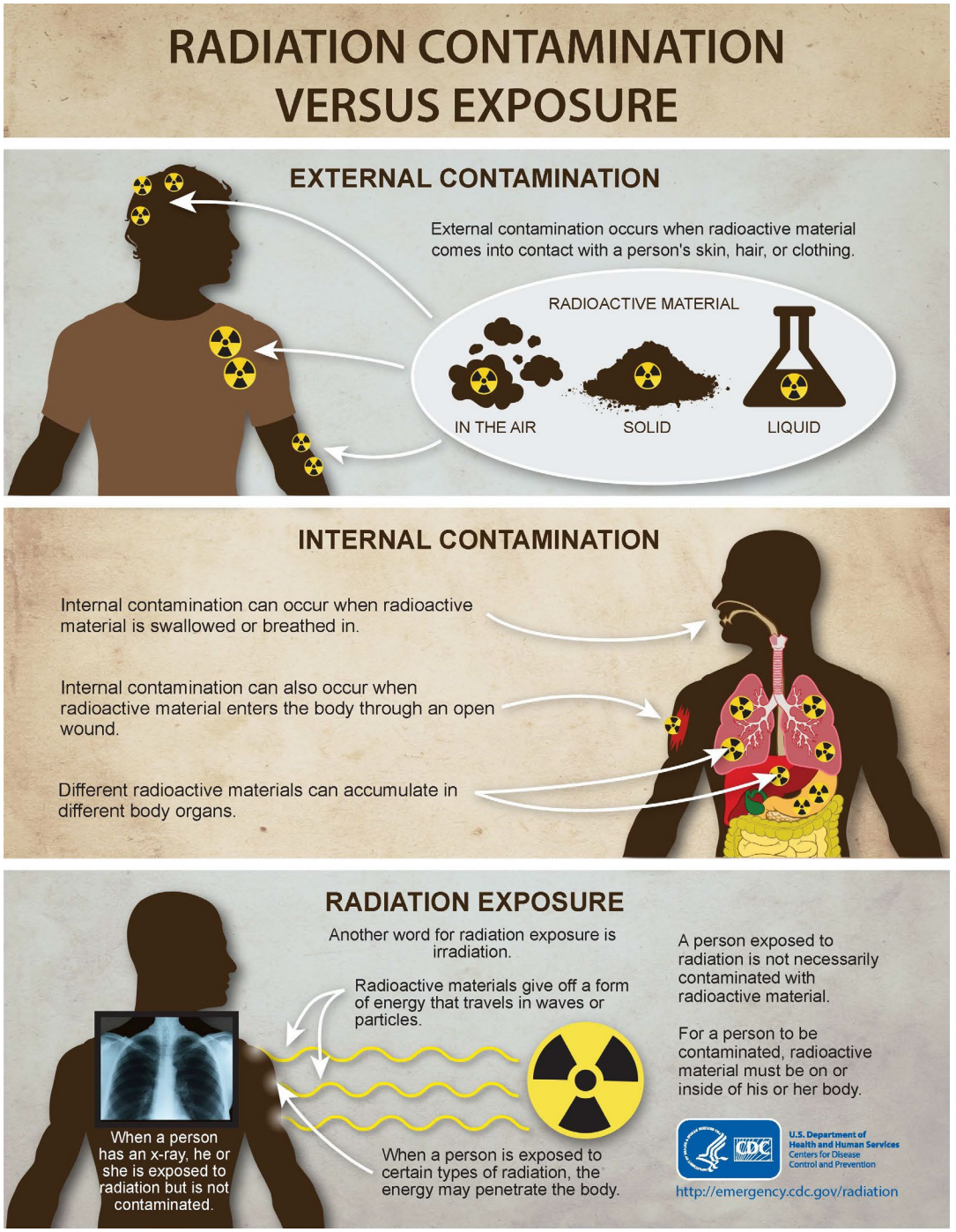


Radiation Effects



Radiation Effects

People will not glow in the dark when contaminated or exposed!



What to do?

STATE OF MAINE

Waldo County Emergency Management Agency

GUIDANCE SUMMARY for COORDINATED PUBLIC MESSAGING
Nuclear Detonation

Revised: 9/4/20

Triggers	Mnemonic	Immediate Action	Rationale
Emergency Alert System (EAS) advisory **Wireless Emergency Alert (WEA) system advisory** **Brilliant white light (flash) is observed**		1. <u>If you are indoors</u>, stay indoors well away from windows. 2. <u>If you are outdoors</u>, seek immediate shelter in a building preferably a concrete structure such as a commercial building or parking structure. 3. <u>If you are driving</u>, pull safely to the side of the road and stop. If a shelter is very close, shelter in that structure. If not, remain in your vehicle and lay on the floor.	• Surviving the immediate effects of a nuclear detonation (blast, shock, thermal radiation, initial nuclear radiation) requires sheltering in resistant structures • You may have only minutes to take protective action – take immediate action without delay • There are no designated blast or fallout shelters in Waldo County.
		1. Remain sheltered until you are told it is safe to leave or two weeks (14 days) have passed, whichever comes first. 2. You may be advised that it is safe to leave your shelter for short periods of time to locate food, water and medical care. 3. Electrical, water and other utilities may be severely disrupted or unavailable.	• Following the detonation, sheltering from radioactive fallout for up to 14 days is critically important • Public may need to briefly leave their shelters to locate essential supplies and equipment • Emergency Management will assess residual radiation levels and advise when sheltering can be discontinued
		1. Listen to local AM-FM radio stations for official information. (EMA Radio 530 AM) 2. Cell phone, television, radio and internet services will be severely disrupted or unavailable. 3. Small portable walkie-talkies may give you communication with nearby shelters.	• Local AM-FM broadcast radio is most survivable and may be useful in advising the public post-detonation • Other communication technologies may be damaged by weapons effects such as EMP[1] • FRS[2] and GMRS radios are widely available in the community and may be useful in keeping people in communication with one another

[1] EMP = Electromagnetic Pulse
[2] FRS = Family Radio Service (unlicensed); GMRS = General Mobile Radio Service (licensed)

RISK AREAS
One Week Dose Range

Protection Factor Using Shelter	High Fallout Risk Area	Med. Fallout Risk Area	Low Fallout Risk Area
PF 5	1200-3000	600-1200	600 rads or less
PF 10	600-1500	300-600	300 rads or less
PF 20	300-750	150-300	150 rads or less
PF 30	200-500	100-200	100 rads or less
PF 40	150-375	75-150	75 rads or less
PF 60	100-250	50-100	50 rads or less
PF 80	75-188	38-75	38 rads or less
PF 100	60-100	30-60	30 rads or less
PF 200	30-75	15-30	15 rads or less
PF 500	12-30	6-12	6 rads or less

RADIATION PENALTY TABLE

Acute Effects	Accumulated Exposure (R) 1 Week	Accumulated Exposure (R) 1 Month	Accumulated Exposure (R) 4 Months
Medical Care Not Needed	150	200	300
Some Need Medical Care Few if Any Deaths	250	350	500
Most Need Medical Care 50% + may die	450	600	600
Lethal Dose	600		

The accumulated exposure should not exceed those in the first row. If radiation levels reach 10/R/hr in the sheltered area, the doses in the first row will probably be exceeded. In this eventuality, the shielding in the sheltered area should be increased. In a full scale attack, about 35% of our population would be expected to exceed the above doses. A PF of 500 is recommended for all fall out shelters.

EXPOSURE AT 30 MILES DOWNWIND
(500 KT surface burst, 15 mph wind)
(Roentgens)

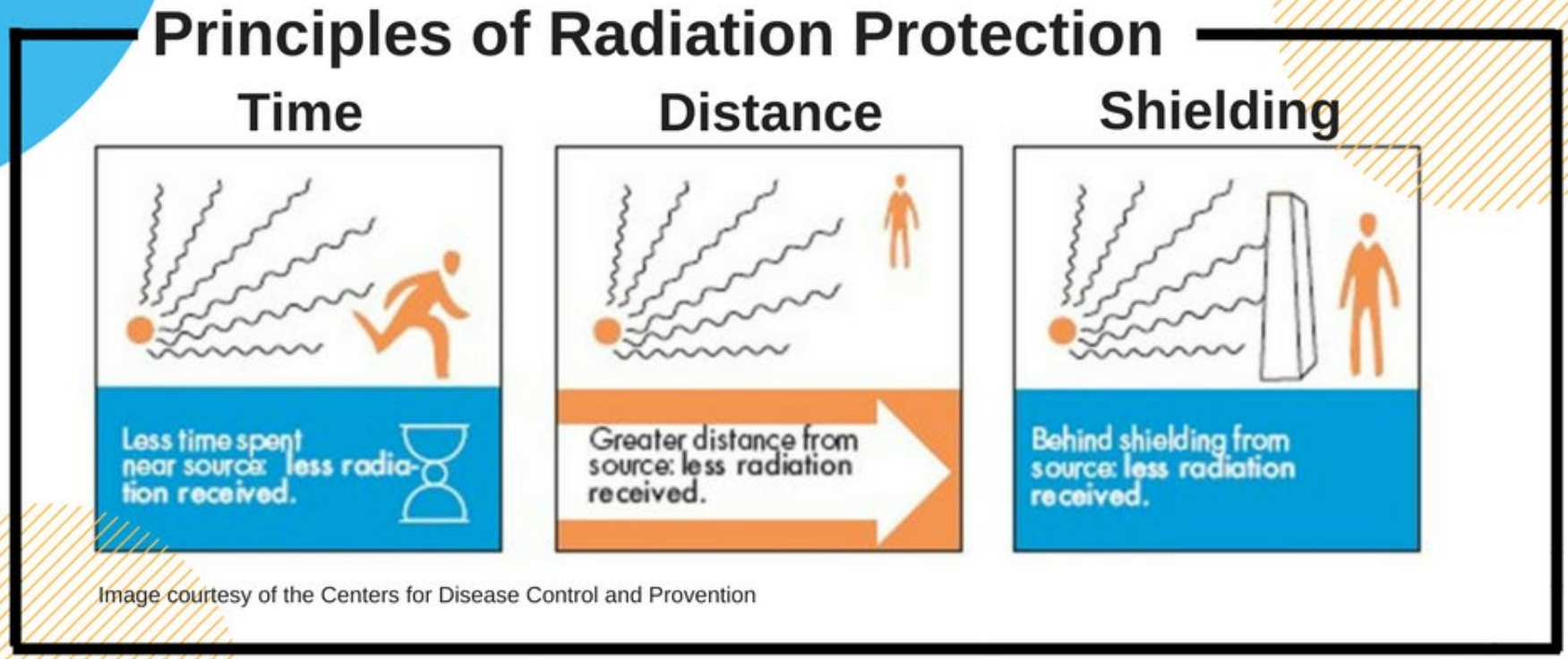
Time	In Open	In Shelter PF 15	In Shelter PF 40
1 Week	3450	230	86
1 Month	4100	273	103
4 Months	4500	300	113

A PF of 40, in this scenario will give the minimum protection not to exceed row one of the Penalty Table above.

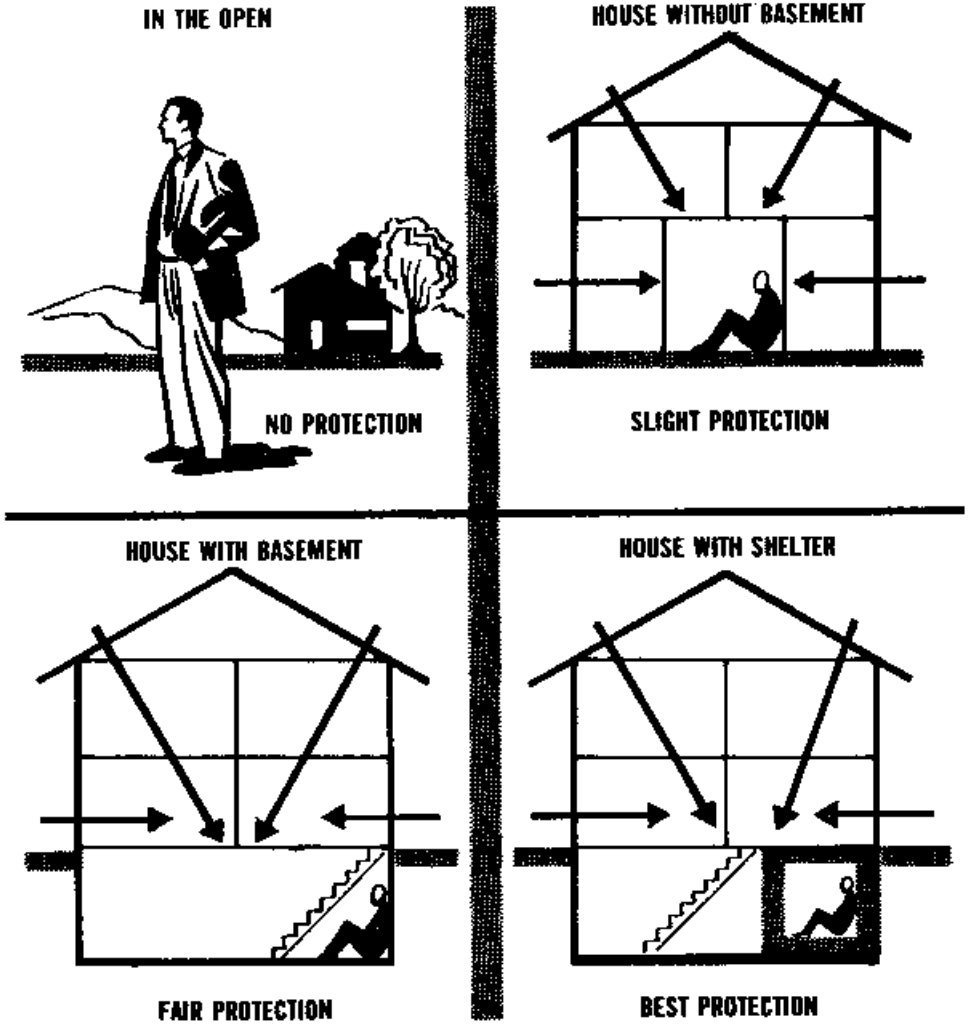
LOW FALLOUT RISK AREAS

Using Shelter Protection Factors	Potential In-Shelter One Week Dose Range	Medical Care Needed	Able To Work	Probable Death Rate	Comments
PF 5	600 R or less	Yes	No	More than 50%	Deaths would occur in about one month
PF 10	300 R or less	Yes	No	Less than 50%	Deaths would occur in 30 to 60 days
PF 20 PF 30 PF 40	150 R or less 100 R or less 75 R or less	No	Yes	Less than 5%	Deaths would occur in 60 or more days
PF 60 PF 80	50 R or less 38 R or less	No	Yes	None	No Symptoms
PF 100 PF 200 PF 300	30 R or less 15 R or less 6 R or less	No	Yes	None	No Symptoms

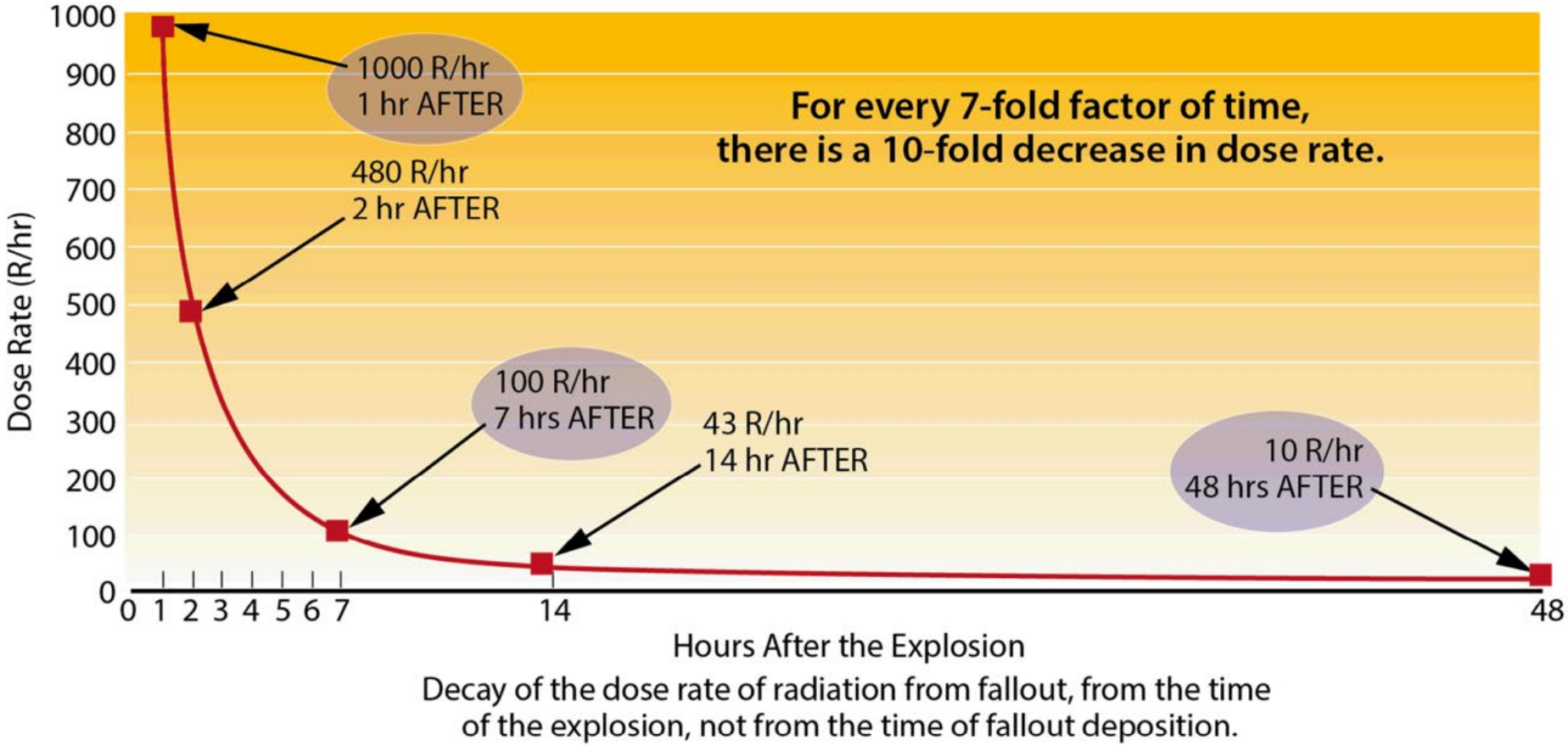
Principals of Protection



Principals of Protection

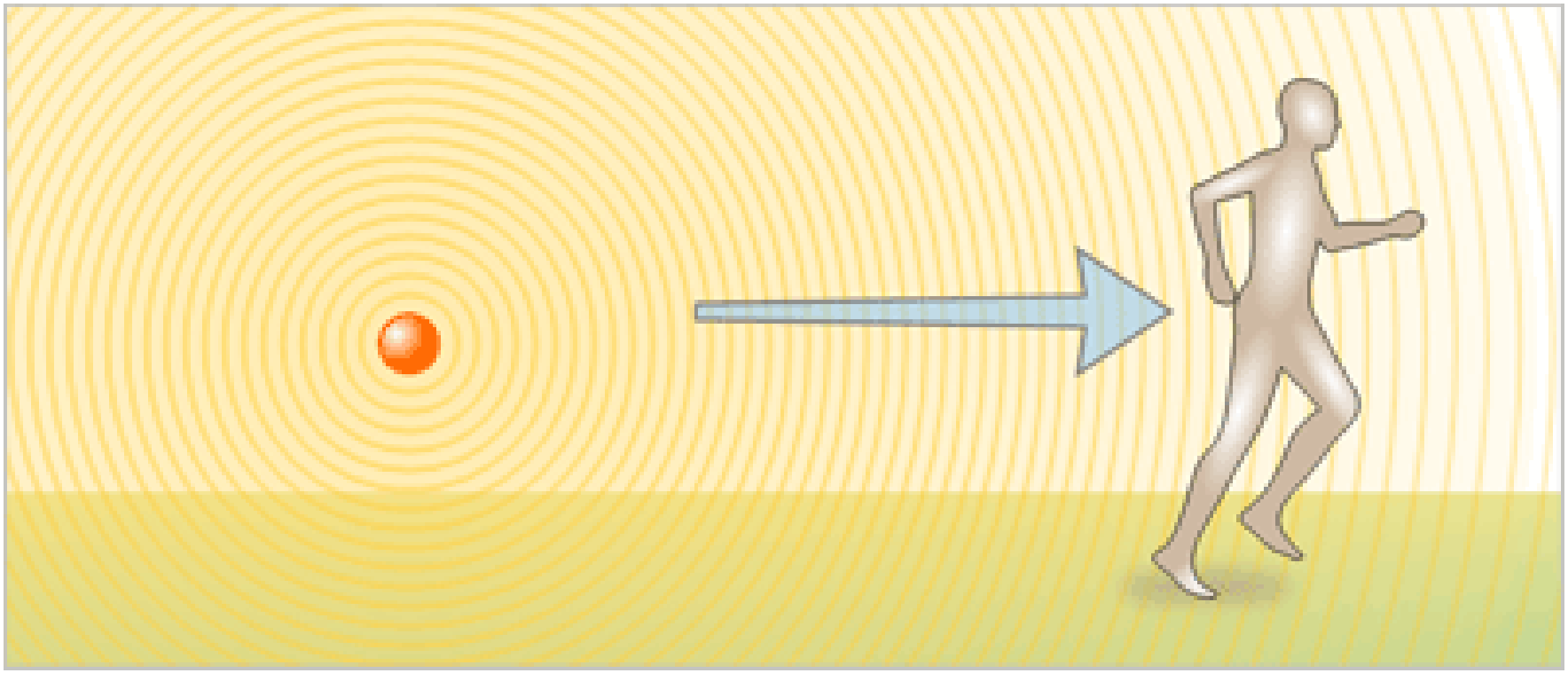


Time (Decay)



Decay of the dose rate of radiation from fallout, from the time of the explosion, not from the time of fallout deposition.

Distance



DISTANCE
INVERSE SQUARE LAW

Dose is inversely proportional to the square of the distance in air from a point of a gamma-ray source.

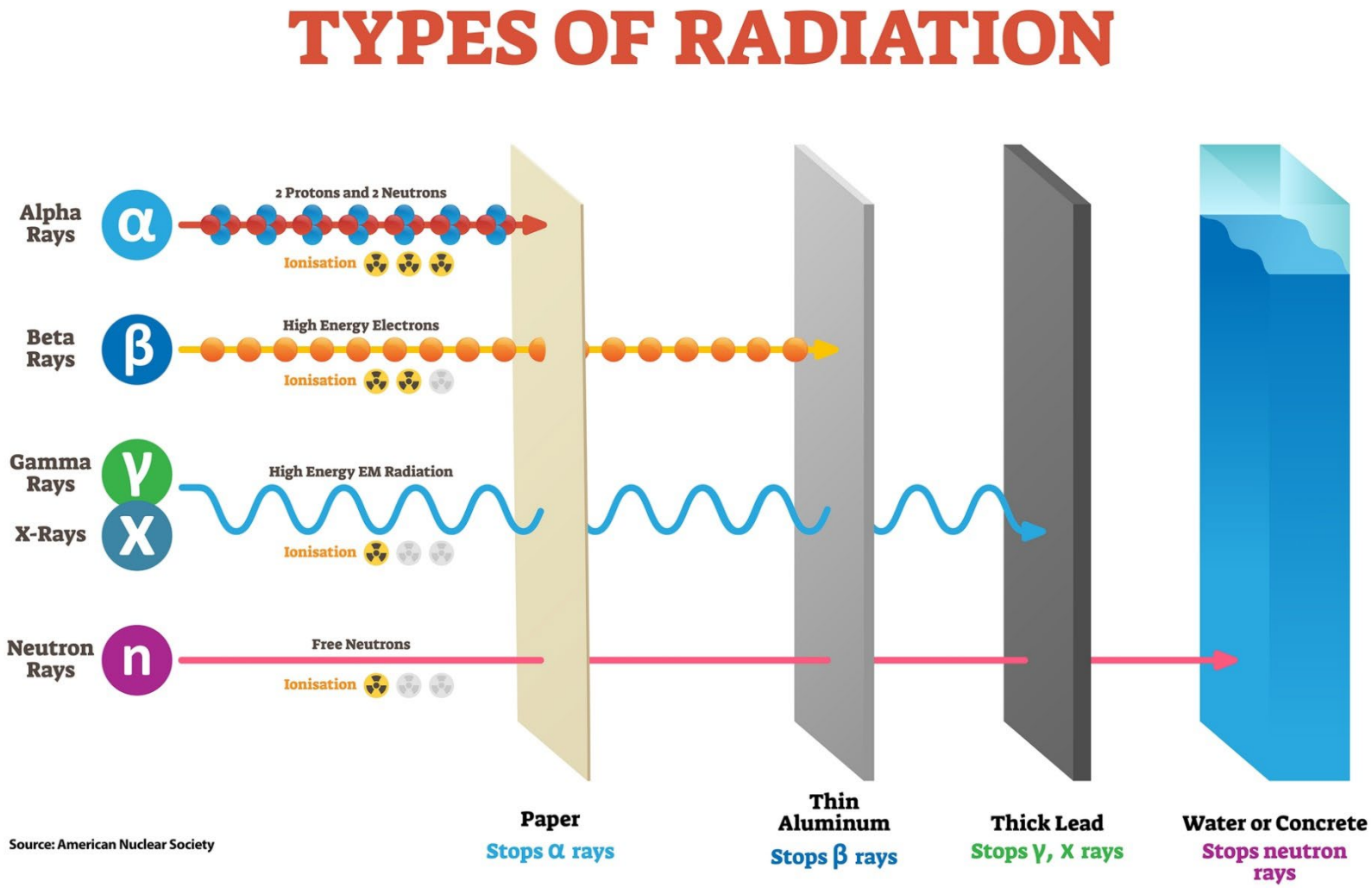
$$(R_2 / R_1) = (d_1 / d_2)^2$$

$$R_2 = R_1 (d_1 / d_2)^2$$

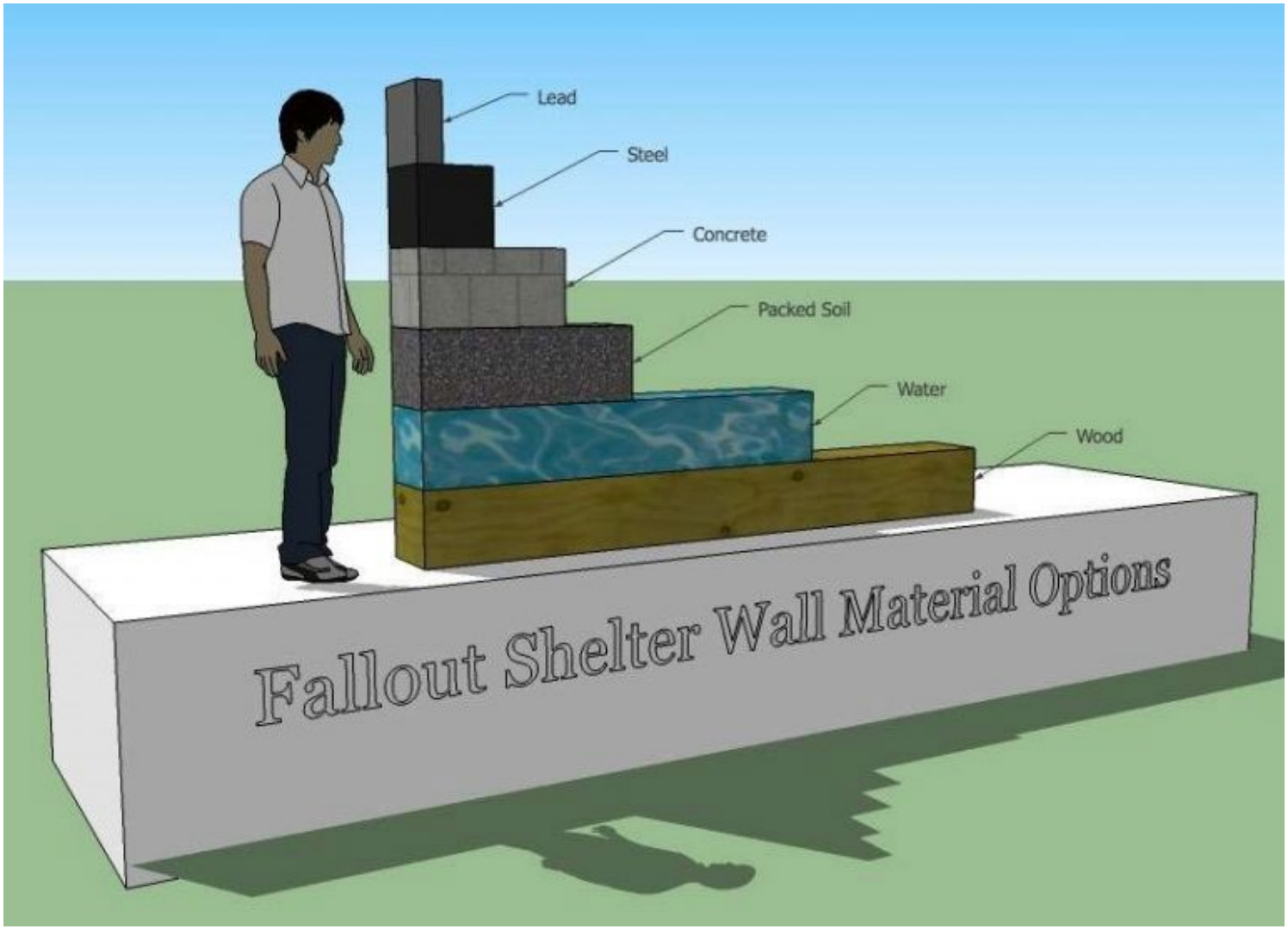
Source*— — — ·10— — — —20— — — -30

1,000 R 250 R 11 R

Shielding


TYPES OF RADIATION
Alpha Rays
α
2 Protons and 2 Neutrons
Ionisation
Beta Rays
β
High Energy Electrons
Ionisation
Gamma Rays
γ
X-Rays
X
High Energy EM Radiation
Ionisation
Neutron Rays
n
Free Neutrons
Ionisation
Source: American Nuclear Society
Paper
Stops α rays
Thin Aluminum
Stops β rays
Thick Lead
Stops γ, X rays
Water or Concrete
Stops neutron rays

Shielding


Lead
Steel
Concrete
Packed Soil
Water
Wood
Fallout Shelter Wall Material Options

Protection Factor (PF)

- The ratio of the fallout exposure rate above a shielded area to the exposure rate below the shielded area.
- A PF of 2 provides protection from half the radiation measured outside a shelter.
  - Outside = 400 R Inside equals = 200 R

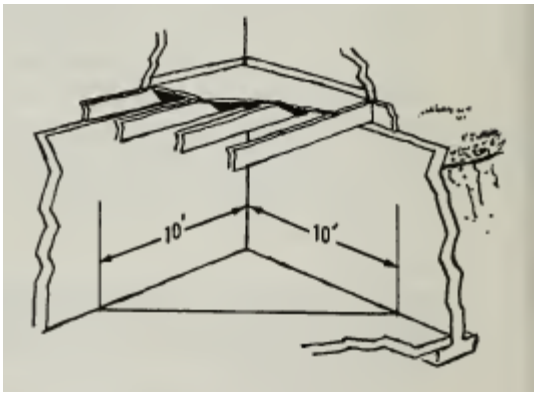
Half-Value Thicknesses

- A half-value thickness of any material will give a protection factor (PF) of 2.

Material	Half-Value Thickness
Concrete	2.4 inch
Earth (compacted)	3.6 inches
Water	6 inches
Wood	11 inches

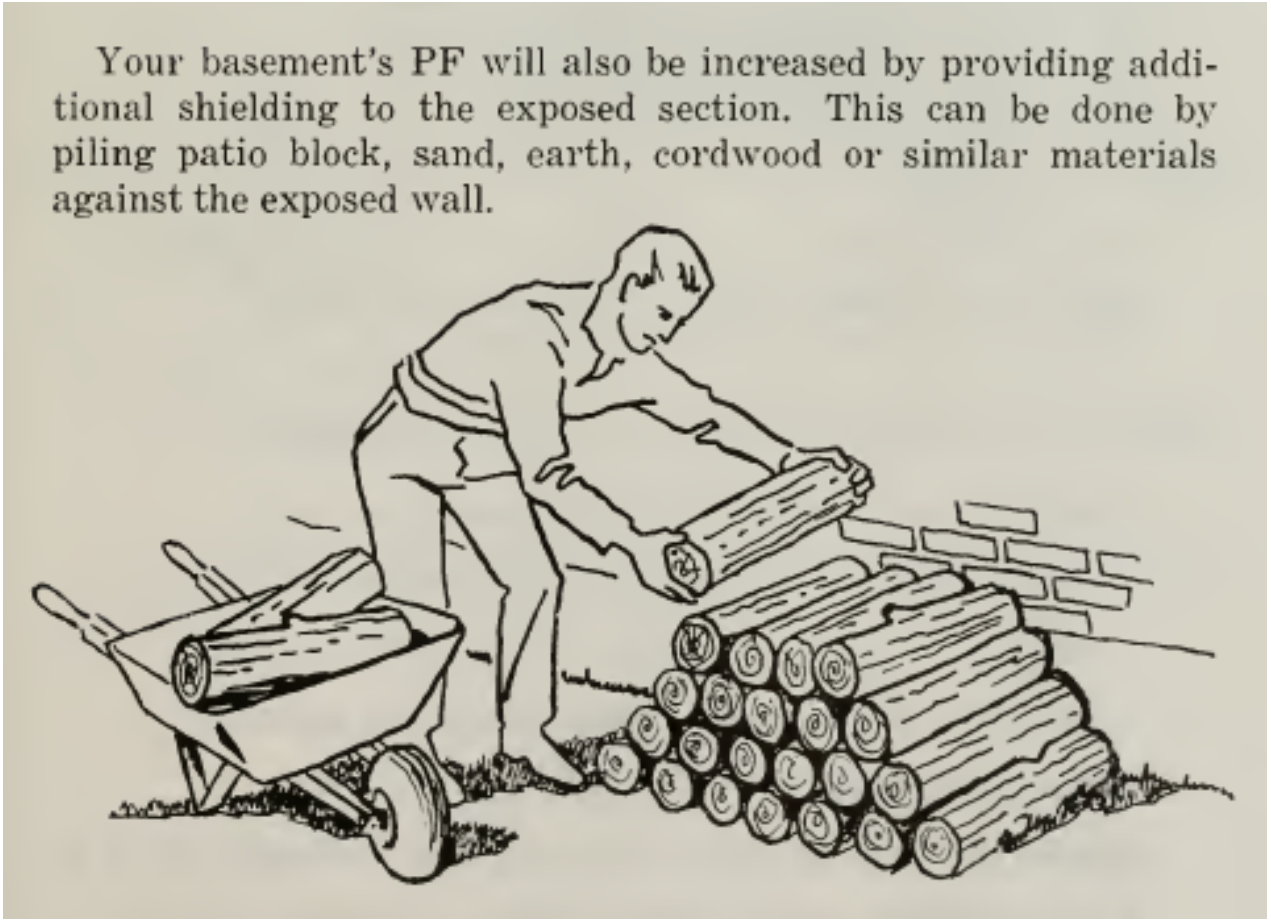
Fallout Shelters

- Create more shielding by constructing a Fallout Shelter.
- Best location is a corner in the basement.
- Best basements are totally below ground.



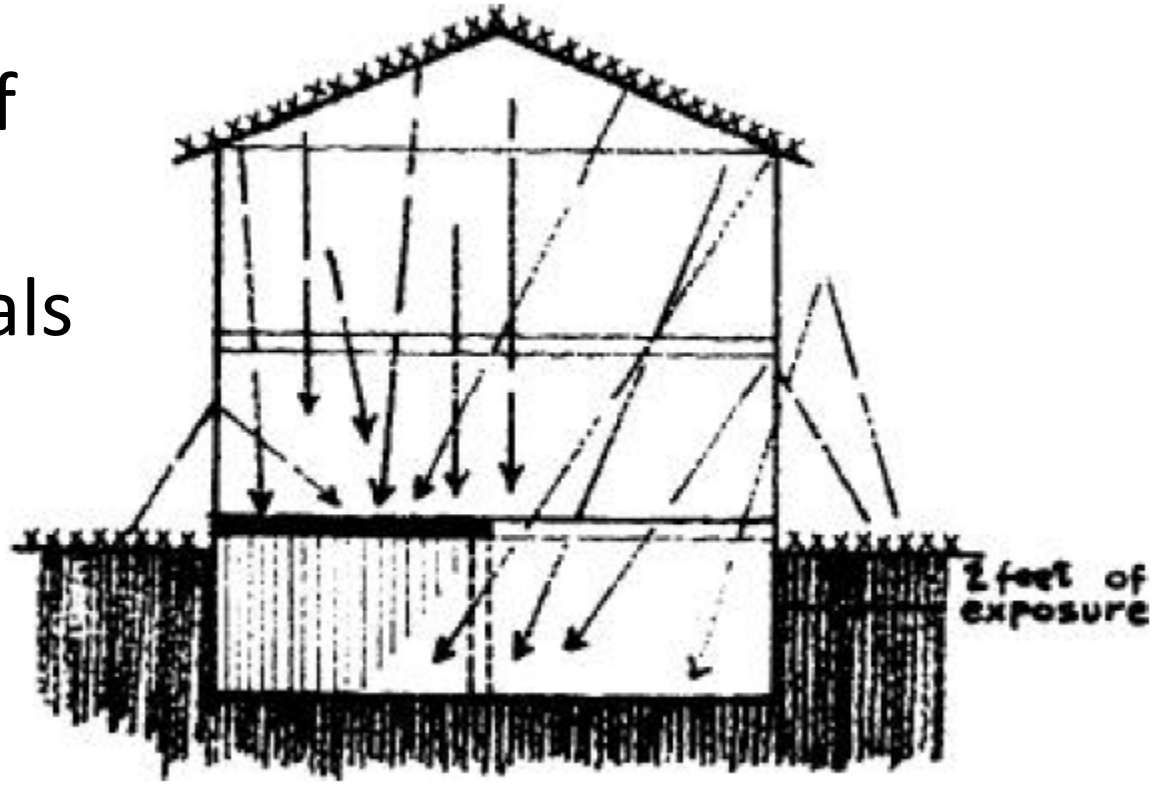
Fallout Shelters

- If basement has windows.

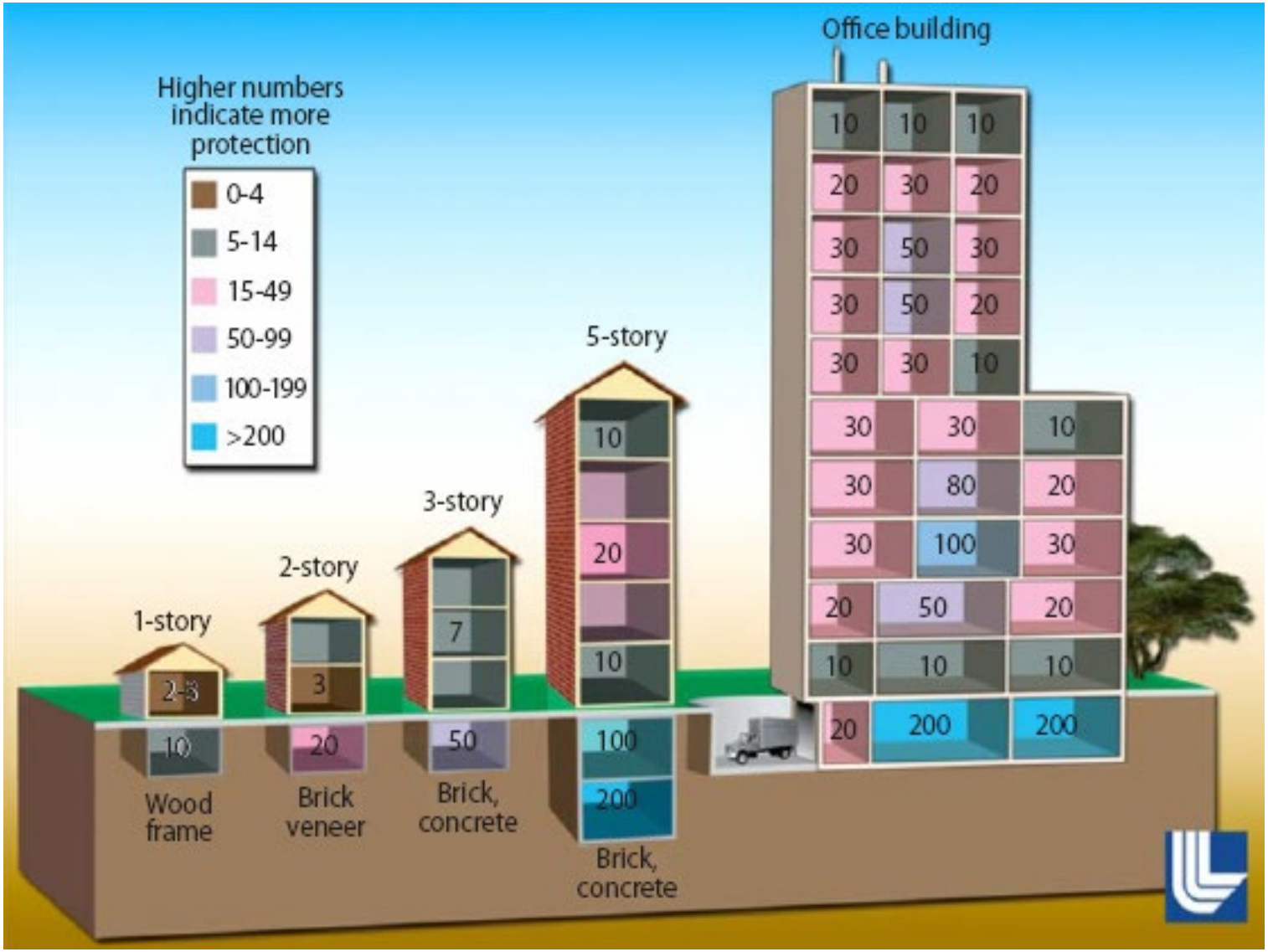


How a Shelter works

- Distance – further from exterior ground and roof
- Shielding – building materials of home and fallout shelter



PF by Building Type



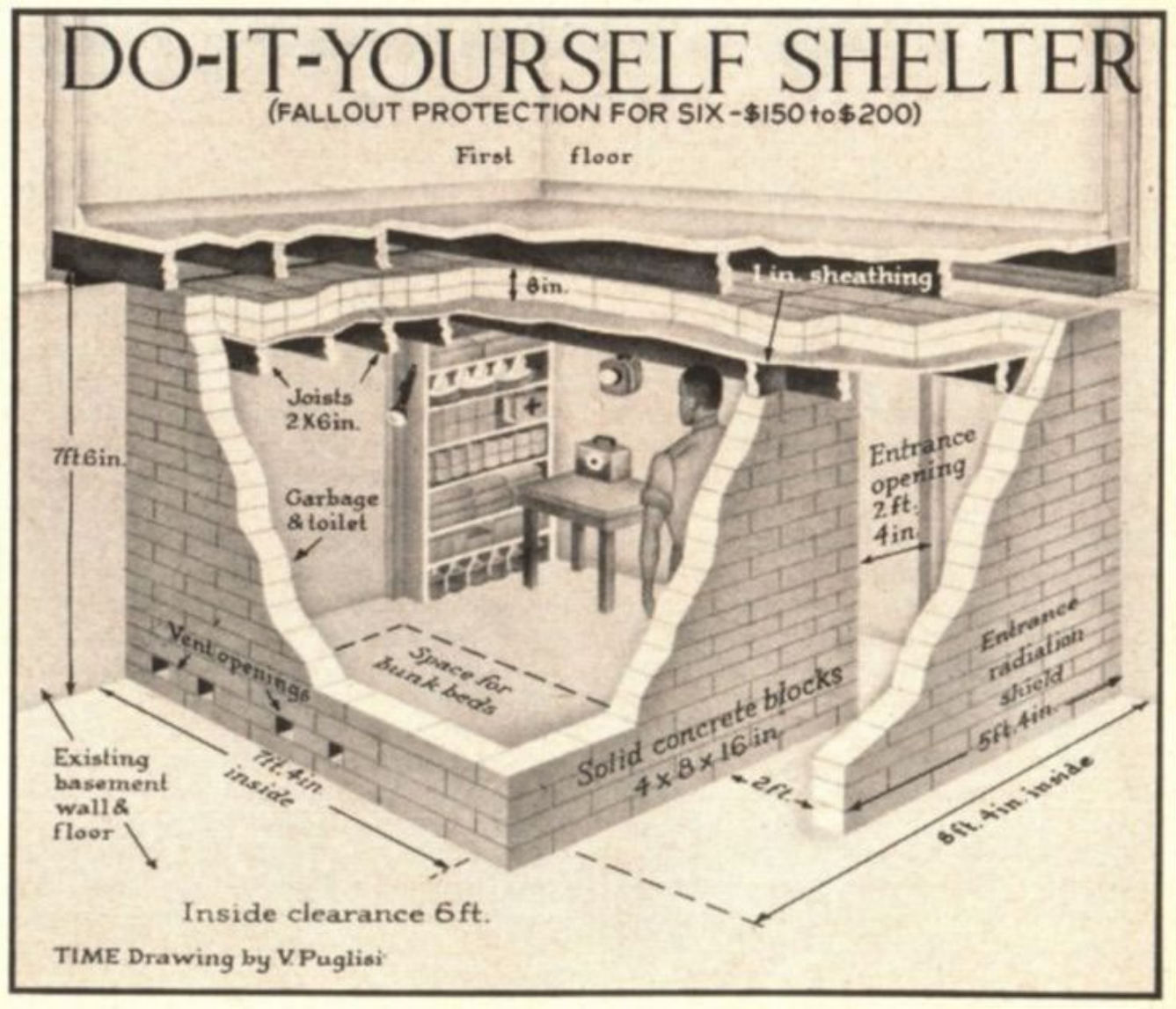
PF Calculations

- Protection Factors are multiplied
- Take the Protection factor of the type of building and multiply it by the shielding that you have added.
- Example – 1 story wood frame home with full buried basement and a shelter made with 8-inch concrete block wall (filled) in corner of basement.
- 8-inches of concrete half 3 times (8-4-2-1) is about PF 8.
- 10’ x 10’ Corner of Basement is PF2
- Basement center is PF 10
- PF = 8 x 2 x 10 = 160
- If outside level is 320 R/hr, you would be exposed to 2 R/hr

Types of Shelters

Types of Shelters

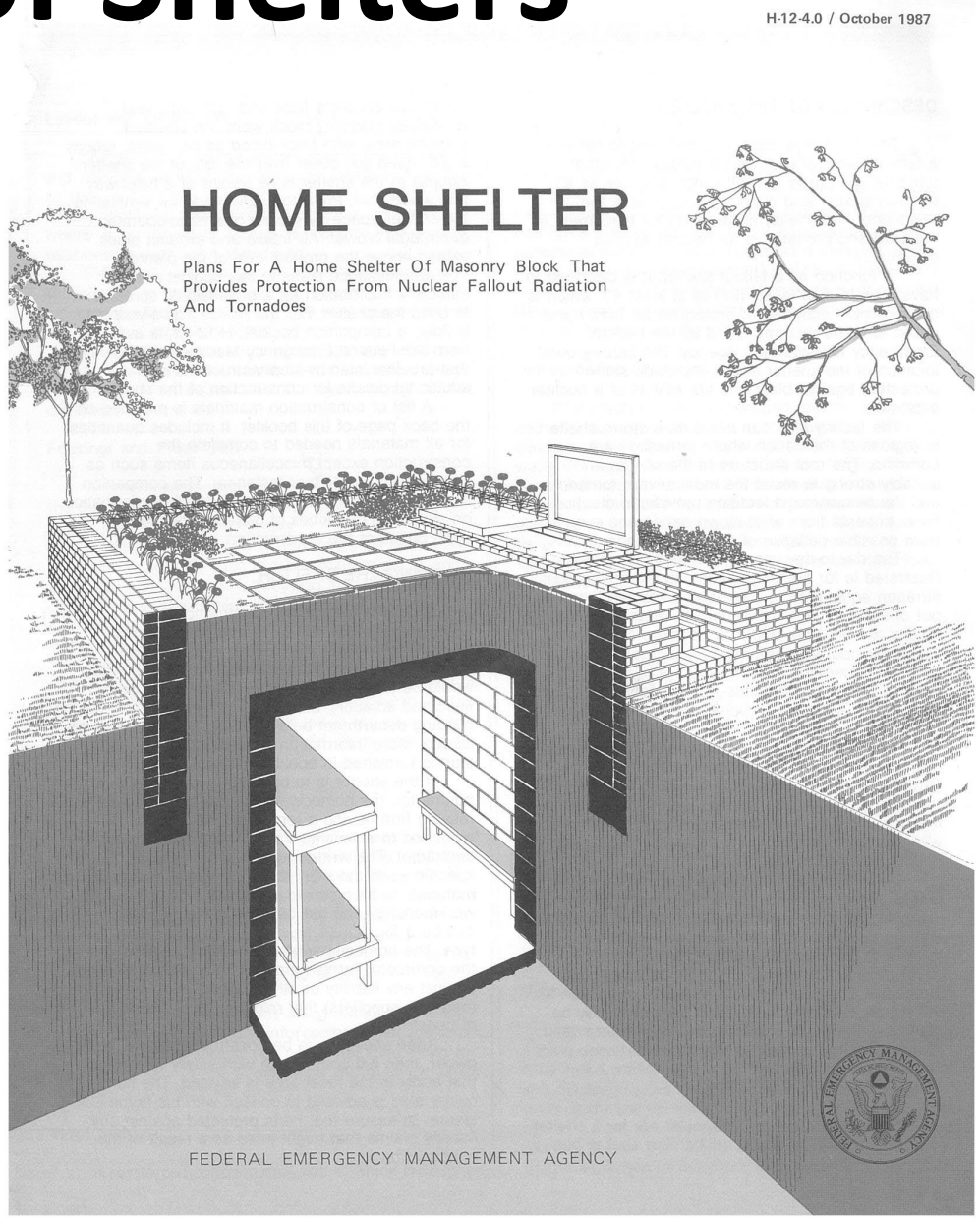
Types of Shelters



I don’t have a basement

- A room in the middle of your house that does not have windows can provide some protection (PF 3)
- An outside shelter either buried or covered up with soil.

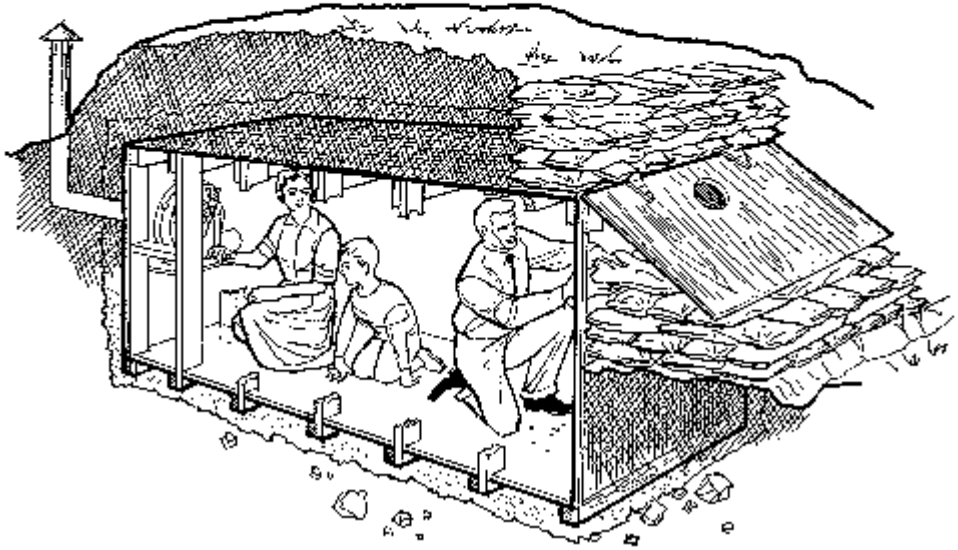
Types of Shelters

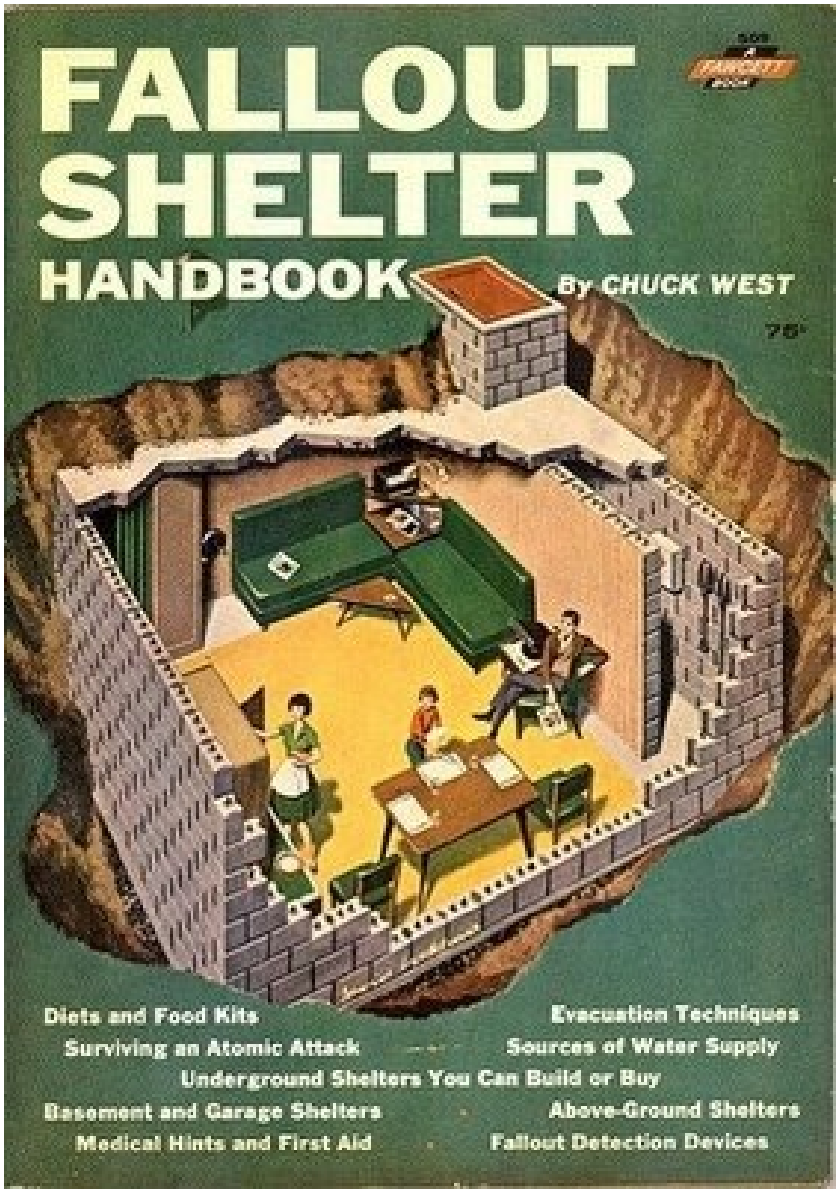


Types of Shelters

FAMILY SHELTER SERIES PSD F-61-4

Outside Semimounded Plywood Box Shelter

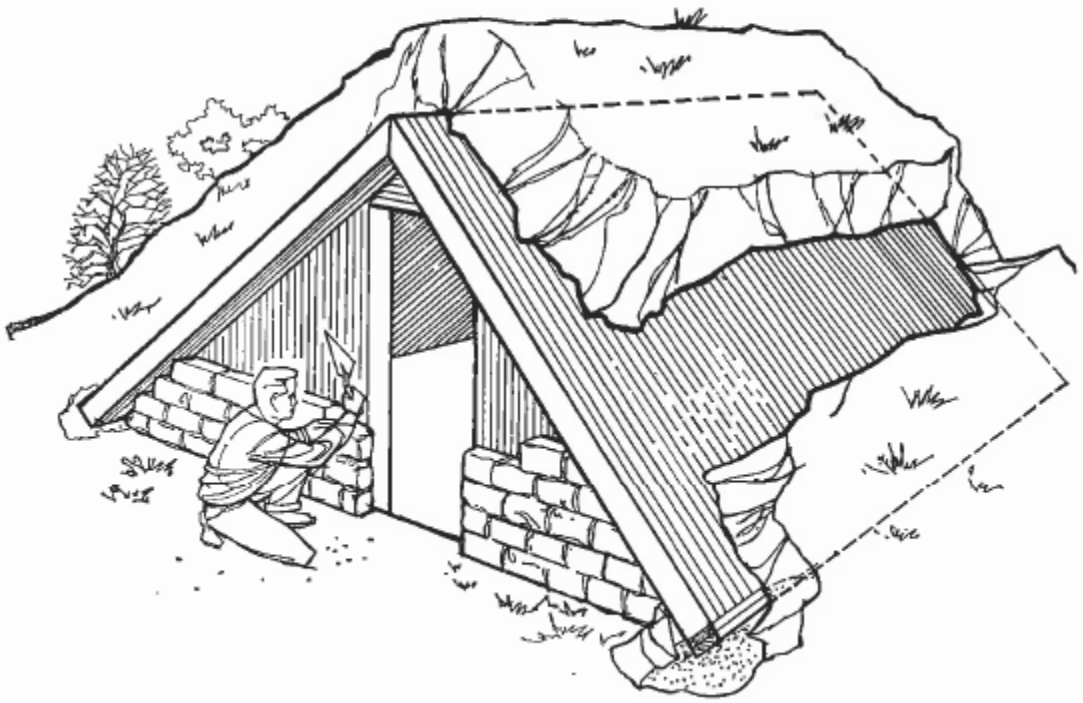




Types of Shelters

FAMILY SHELTER SERIES PSD F-61-7

Aboveground Earth-Covered Lumber A-Frame Shelter



Other Shelter Considerations

- Minimum of 10 sq. ft. of net floor area per shelter occupant.
- Minimum head room of 6.5 ft.
- Minimum of 3 cu. ft. of fresh air per minute per fallout shelter occupant to prevent oxygen depletion and carbon dioxide buildup.
- Heating/Warmth – minimum of 50 deg F
- Battery operated lighting (candles will utilize fresh air)

Other Shelter Considerations

- Fire Safety/Extinguisher
- Sanitation/Toilets
- Drinking Water
- Food (precooked)
- First Aid Supplies
- AM/FM Radio
- GMRS or Ham Radio
- Sleeping Cot, Bed, Air mattress, etc
- Extra Clothes

Radiation and Fallout

- Questions?