

What About Nuclear Waste?

Philip D. Wheatley
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Outline

- Radioactivity
- Waste comparison and risks
- Waste classifications
- Examples of radioactive wastes
- Radioactive waste disposal
 - Spent nuclear fuel
 - Low-level waste
- Transportation of wastes
- Class exercise

Radioactive Material and Radioactivity

- Radioactive material is any material that spontaneously emits ionizing radiation.
- Process of unstable atom emitting radiation is called radioactivity.
- When a radioactive atom goes through the process of radioactivity, also called radioactive decay, it will change to another type of atom.

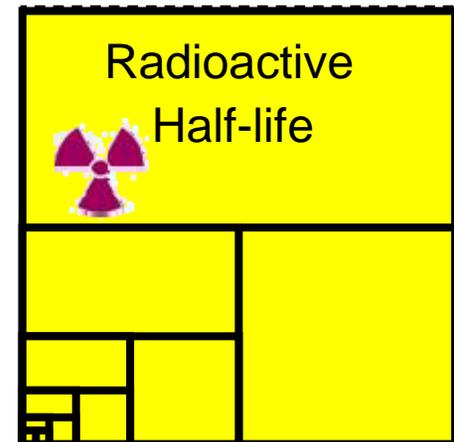
Radioactive Material and Radioactivity

- Radioactive decay is measured in half-lives.
- Half-life is the time it takes for $\frac{1}{2}$ of the radioactive atoms present to decay to another form.
- Half-life is unique to each radioactive isotope and can vary greatly.
- Radioactive pharmaceutical products (called radiopharmaceuticals) typically have half-lives of a few hours or days.

Radioactive Material and Radioactivity

- Regardless of the half-life, the radioactivity level of any given amount of radioactive material is constantly decreasing.

Some radioactive isotopes and their half-life	
Isotope	Half-Life
Nitrogen-16	7 seconds
Technetium-99m	6 hours
Thallium-201	73 hours
Cobalt-60	5 years
Cesium-137	30 years
Americium-241	432 years
Uranium-238	4.5 billion years



Common Radiation Dose Limits

Limits	Dose (mrem/yr)
EPA Drinking Water	4
EPA Air	10
NRC Site Cleanup for Unrestricted Use	25
DOE/NRC Dose Limits for Public	100
Natural Background	300
Airline Pilots	200-400
DOE/NRC Limit for Workers	5000

Doses in Comparison - Acute

Function/Procedure	Dose (mrem)
Chest X-ray	4
Panoramic dental X-ray	9
Lumbar Spine X-ray	70
Mammogram (four views)	70
Abdomen X-ray	120
Heart stress test (Tc-99m)	585
Heart stress test (Tl-201)	1,180
CT of abdomen or pelvis	1,000
Various PET studies (F-18)	1,400
Coronary angiogram	1,580
Angioplasty (heart study)	5,700

Waste Comparisons

All the commercial nuclear waste would fit in any high school football stadium.



In the United States:

**Waste from all nuclear power
(20% of U.S. power supply)**

~ 2,000 tons/yr

**Waste from all coal fired power plants
(50% of U.S. power supply)**

**~ 400,000,000 tons/yr
~ 2,000,000,000 tons CO₂
radwaste ?**

**Commercial SNF Production
Coal Ash Waste (60%/40%)**

**7 inch/yr to a football field
5.4 miles/yr to a football field**

Understanding Risk

Activity	Number of Deaths in U.S. over the past 5 years
iatrogenic (<i>medicine gone wrong</i>)	950,000
smoking	760,000
alcohol	500,000
automobile accidents	250,000
coal use (~ 50% of U.S. power)	70,000
food poisoning	25,000
construction	5,000
hunting	4,100
nuclear industry (~ 20% of U.S. power)	0

Understanding Risk

Activity	Number of Deaths in U.S. Normalized to Sub-Population	Relative Danger Index
smoking (43.4 million smokers)	760,000	0.01751
alcohol (60 million impacted Americans)	500,000	0.00833
iatrogenic (180 million receive medical treatment per/yr)	950,000	0.00527
automobile accidents (180 million drivers)	250,000	0.00138
police work (680,000 police officers)	800	0.00118
mining (350,000 miners)	359	0.00103
construction (7.7 million workers)	5,000	0.00065
hunting (12.5 million hunters)	4,100	0.00033
coal use (~ 50% of U.S. power) (240 million impacted)	70,000	0.00029
nuclear industry (~ 20% of U.S. power) (60 million)	0	0.00000

The Definition of High-Level Nuclear Waste:

“Well, it is a radius that is applied to it on a high level in a way that you are going to treat that way, and the way that you are then going to process it. So at the end of that, on a high level, let’s say you might have to – after processing that, you may – before you put it in the permanent storage, that may be something that you have to transport to let’s say – to where we were putting storage in New Mexico. Some other kind of waste you would be able to put in the cement and store it right there on the site. High level, we would handle that with care. We handle all of it with care.”

DOE Assistant Secretary
Lawrence F. Davenport

Radioactive Waste Classifications

- High Level Waste (HLW)
 - Government reprocessing waste in either
 - liquid or
 - solid form
 - All government owned at four sites
- Spent Nuclear Fuel (SNF)
 - Irradiated commercial and government reactor fuel
 - More that 100 power reactors within the U.S.
 - University research reactors
 - DOE research reactors
 - Navy reactors

Radioactive Waste Classifications

- **Transuranic Waste** – Waste containing elements with atomic numbers greater than 92, the atomic number of uranium. TRU includes only waste material that contains transuranic elements with half-lives greater than 20 years and concentrations greater than 100 nanocuries per gram, disposal at the Waste Isolation Pilot Plant in New Mexico.
- **Low-Level Waste (LLW)** – “Low-level” radioactive waste is defined by what it is not, it thus includes everything from slightly radioactive trash (such as mops, gloves, and booties) to highly radioactive activated metals from inside nuclear reactors. It includes both short-lived and long-lived radionuclides.
 - **Class A** – On average the least radioactive of the four LLW classes. Primarily contaminated with “short-lived” radionuclides.
 - **Class B** – May be contaminated with a greater amount of “short-lived” radionuclides than Class A.
 - **Class C** – May be contaminated with greater amounts of long-lived and short-lived radionuclides than Class A or B.
 - **Greater than Class C** – Most radioactive of the low-level classes, limits disposal methods.

Waste Classification Limits

Radionuclide	Class A (Ci/m ³)	Class B (Ci/m ³)	Class C (Ci/m ³)
Total of all nuclides with less than 5 year half life	700	No limit	No limit
H-3 (Tritium)	40	No limit	No limit
Co-60	700	No limit	No limit
Ni-63	3.5	70	700
Ni-63 in activated metal	35	700	7000
Sr-90	0.04	150	7000
Cs-137	1	44	4600

A radiotherapy machine may have roughly 1000 Ci of a radioisotope such as cesium-137 or cobolt-60. This quantity of nuclear material can produce serious health effects with only a few minutes of exposure.

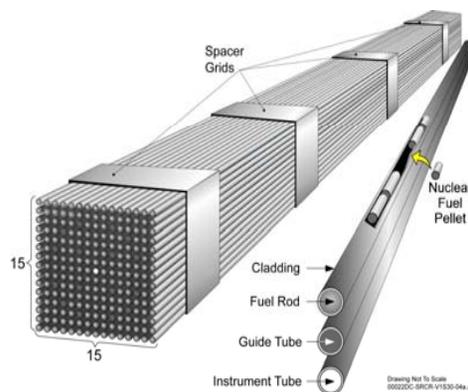
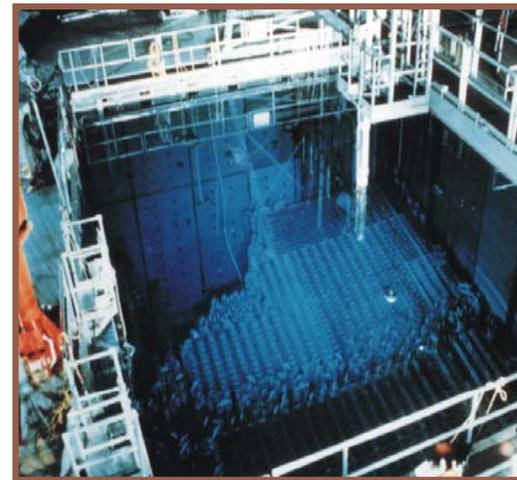
Examples of Radioactive Waste

- Ion exchange resins and filter materials used to clean water at a nuclear power plant.
- Contaminated hand tools, components, piping, and other equipment from nuclear power plants and other industries.
- Research equipment from laboratories where radioactive materials are used.
- Shoe covers, lab coats, cleaning cloths, paper towels, etc., used in an area where radioactive material is present.
- Containers, cloth, paper, fluids, and equipment which came in contact with radioactive materials used in hospitals to diagnose or treat disease.

Sources of Radioactive Waste

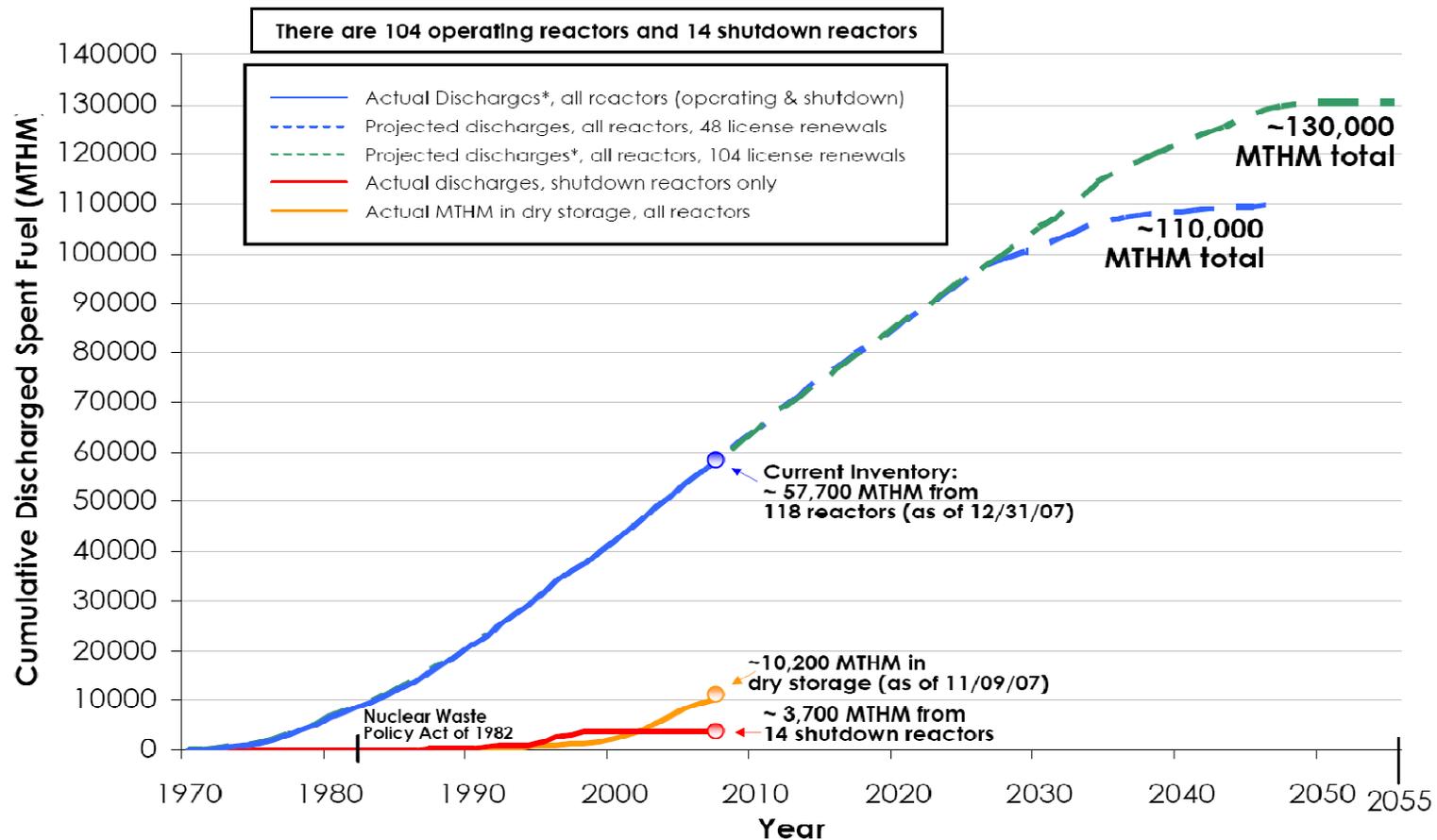
- Nuclear power plant
 - LLW, e.g. protective clothing, shoe covers, paper, construction materials, reactor equipment, resins
 - SNF, discharged after useful life

Spent fuel is stored in large pools of water



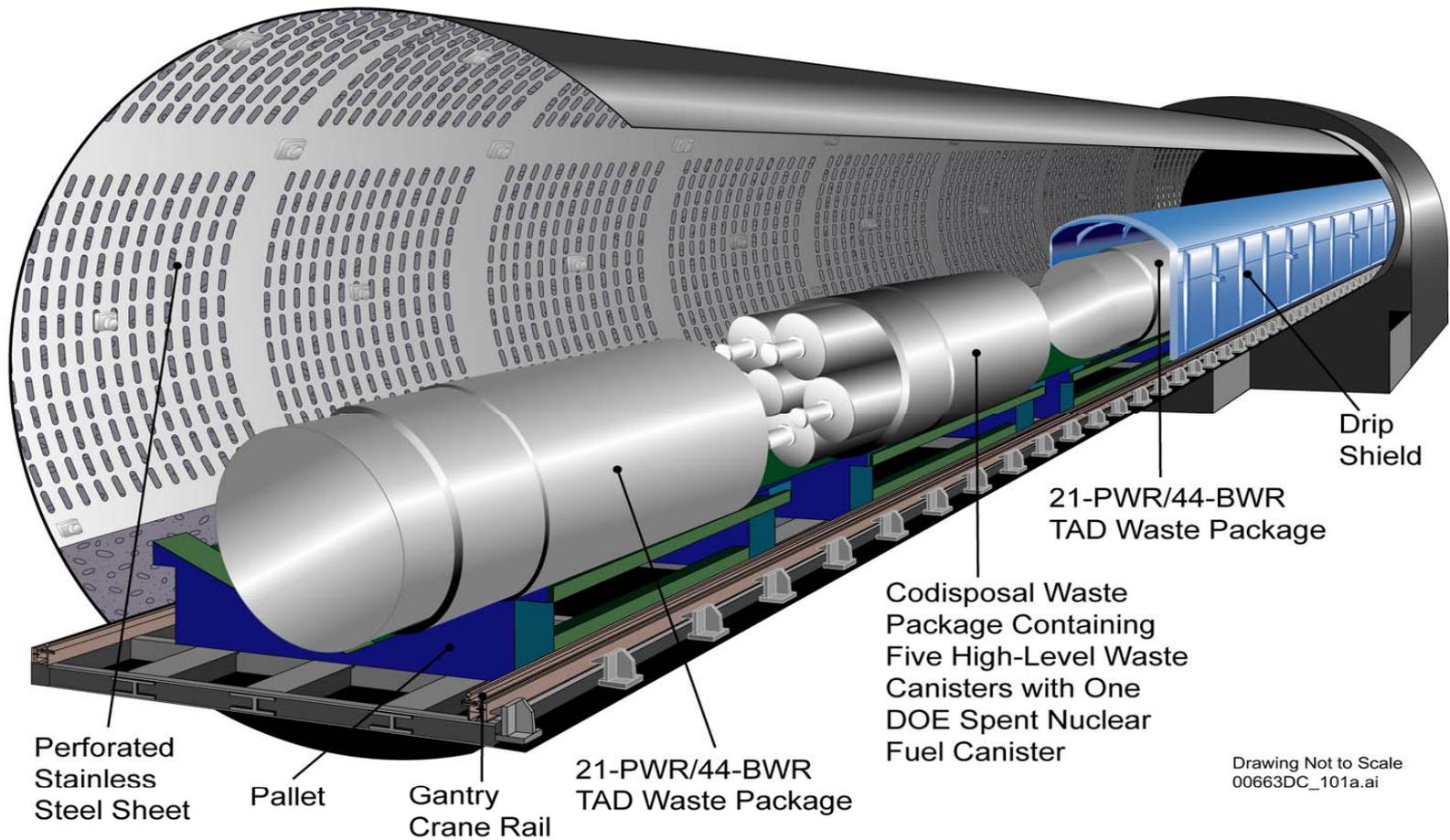
Or, spent fuel is stored in above-ground dry casks

Historical and Projected Commercial Spent Nuclear Fuel Discharges



Sources: * Based on actual discharge data as reported on RW-859's through 12/31/02, and projected discharges, in this case, based on 104 license renewals.

Emplacement Drift

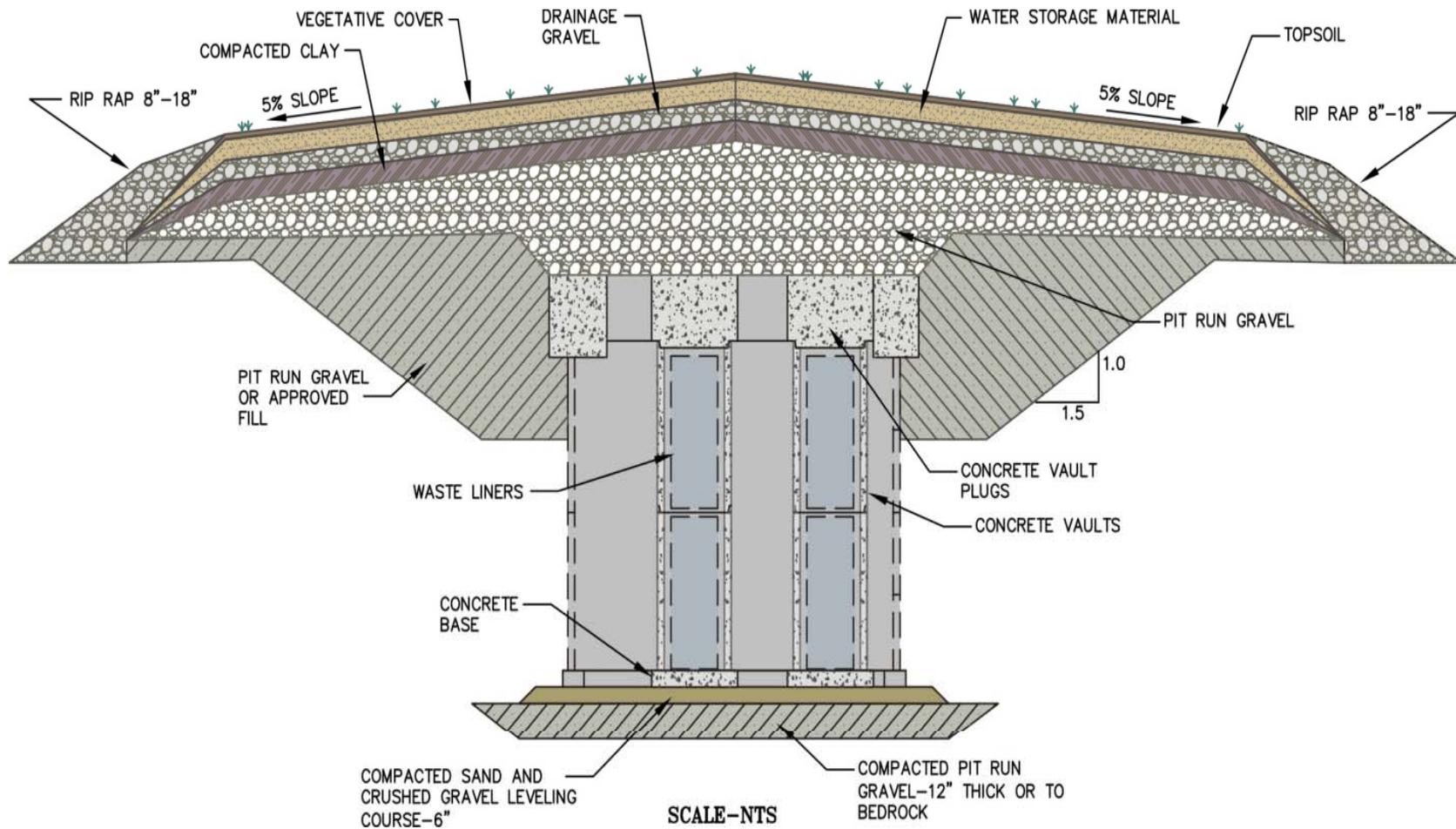


Information supplied by DOE OCRWM

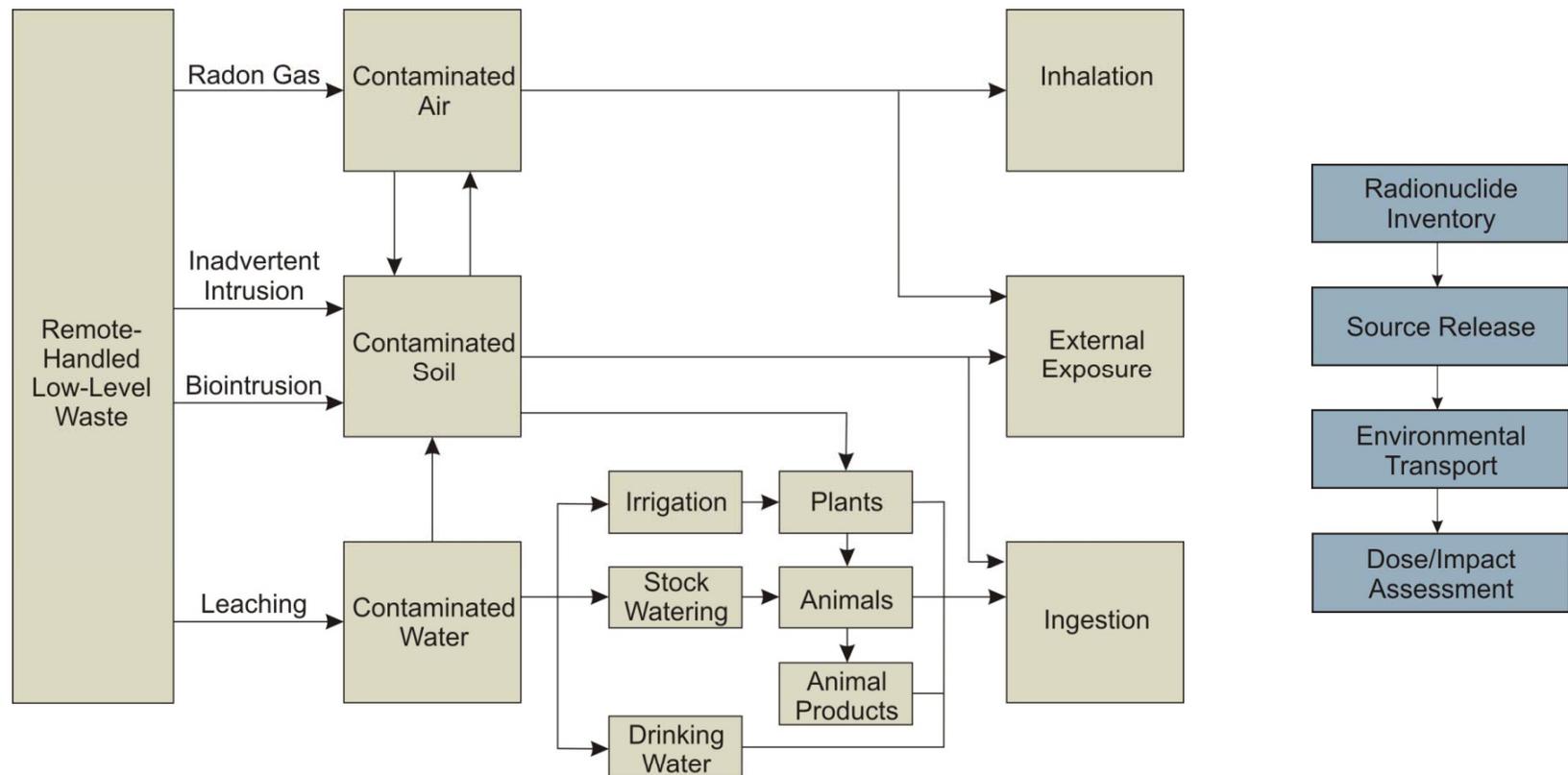
Low Level Waste Volume and Activity by Disposal Facility – 2008

Disposal Facility	Volume (Cubic Feet)	Activity (Curies)
Clive	2,040,296	4,694
Barnwell	22,278	762,018
Richland	22,791	16,452
TOTAL	2,085,366	783,164

Facility Proposed Cover Design



Exposure Pathways



U.S. Shipping Activity

- 500 billion packages shipped annually in U.S.
- 400 million are hazardous.
- Approximately 3 million are radioactive.
- 5,000 to 20,000 DOE radioactive material and waste shipments per year.

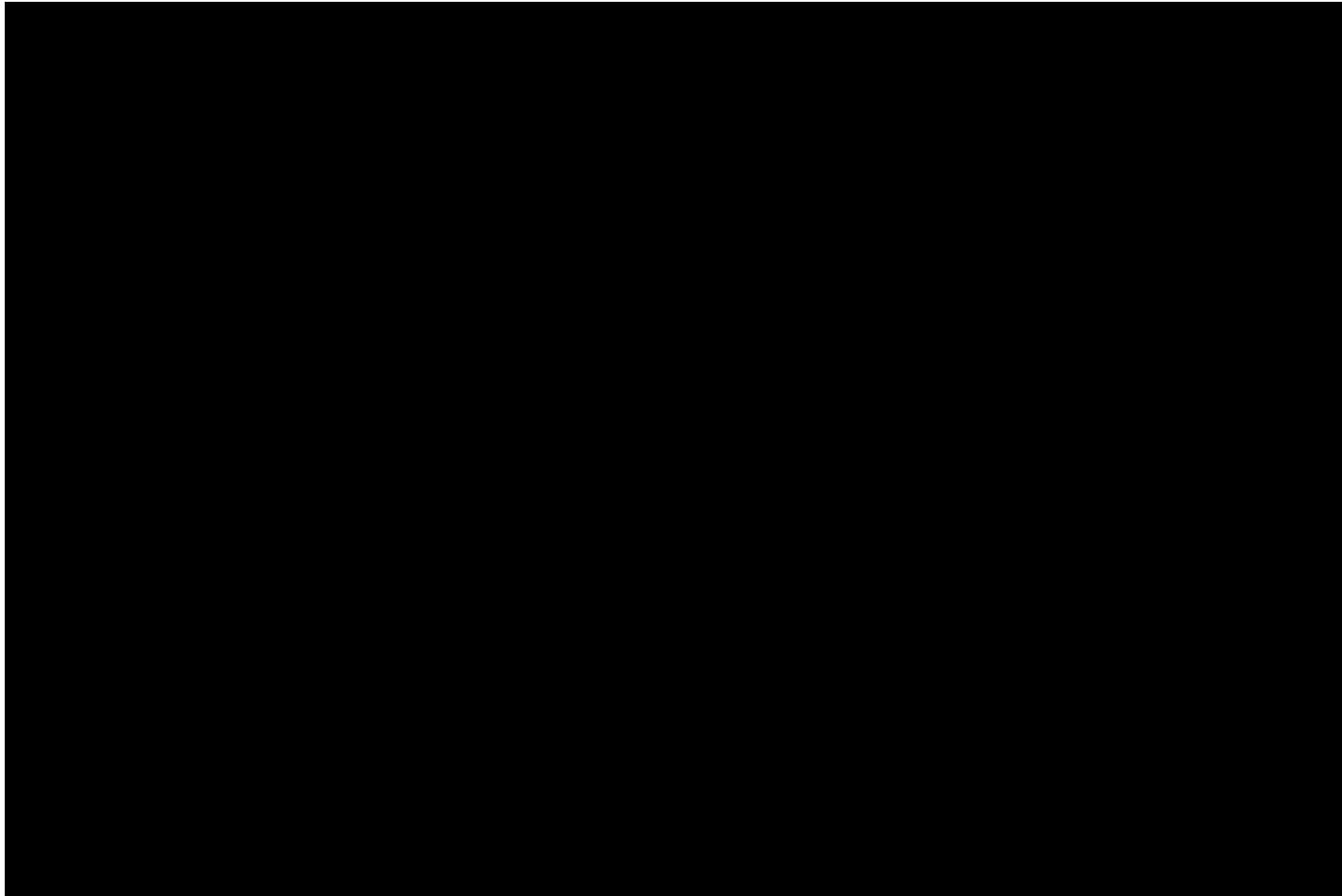
Transporting Radioactive Material

- Radioactive materials are a vital part of our modern society.
- They are used in hospitals, factories, laboratories, and our homes.
- Radioactive material is generally shipped in its most stable form.

**January 2007, high activity waste began shipping to WIPP;
up to 1000 R/hr surface**



Transportation Packaging - Video



Class Exercise Facts About Radioactive Waste

<p>Facts By Phil</p>	<p>Not much waste by volume compared to other energy sources</p>	<p>Largest volume is LLW with low hazard</p>	<p>Low relative risk very by comparison</p>	
				<p>Conclusion</p> <p>Nuclear power can be an environmental sound, safe and cost effective energy source</p>