

Radioactive Wastes *and Rolling Stewardship*

A Slide Show

prepared for
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Nuclear Fission

The End of an Era

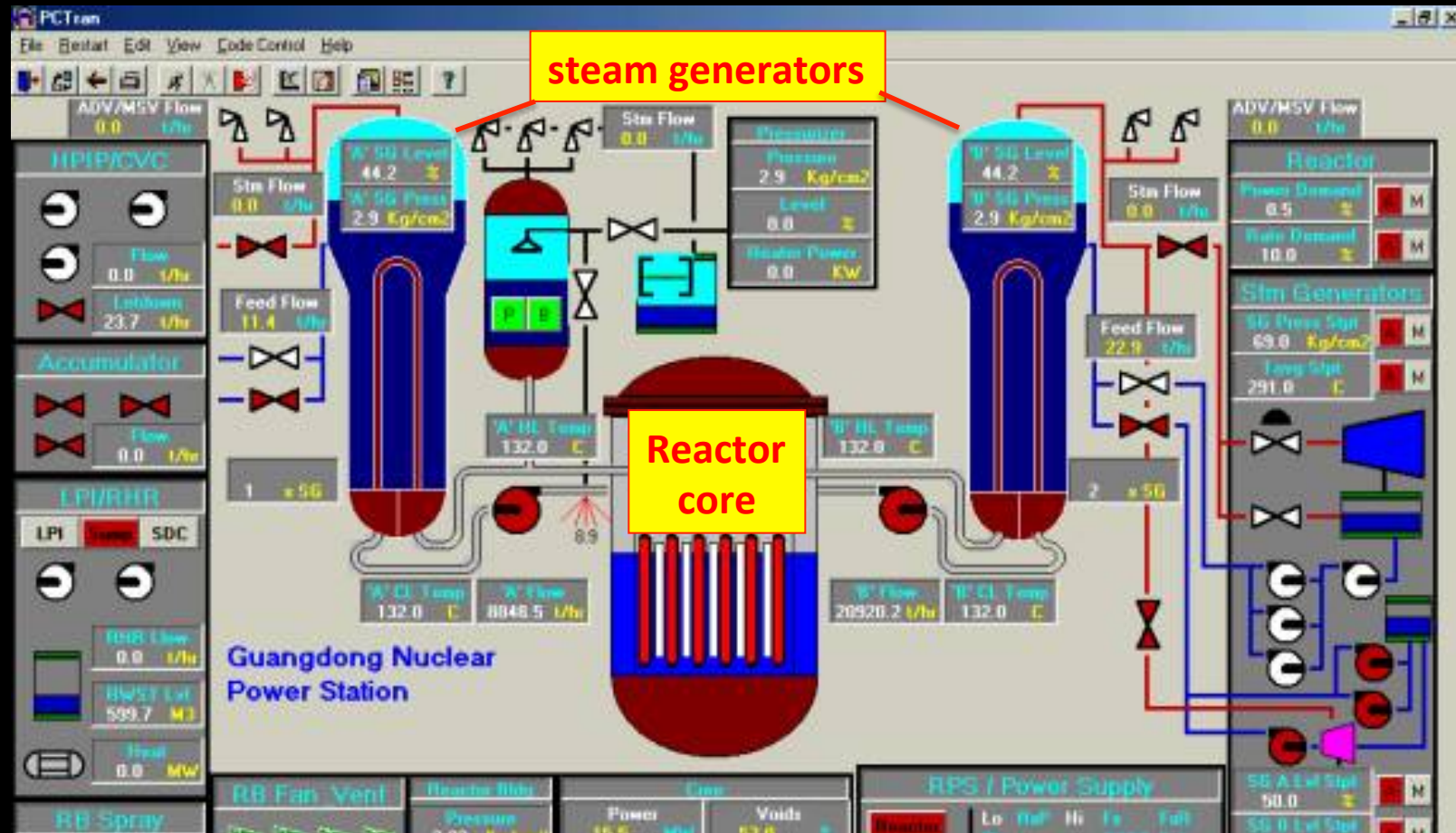
*The Forsmark 3
Nuclear Reactor*

*“The Age of Nuclear Power is Winding Down
but the Age of Nuclear Waste
is just beginning”*



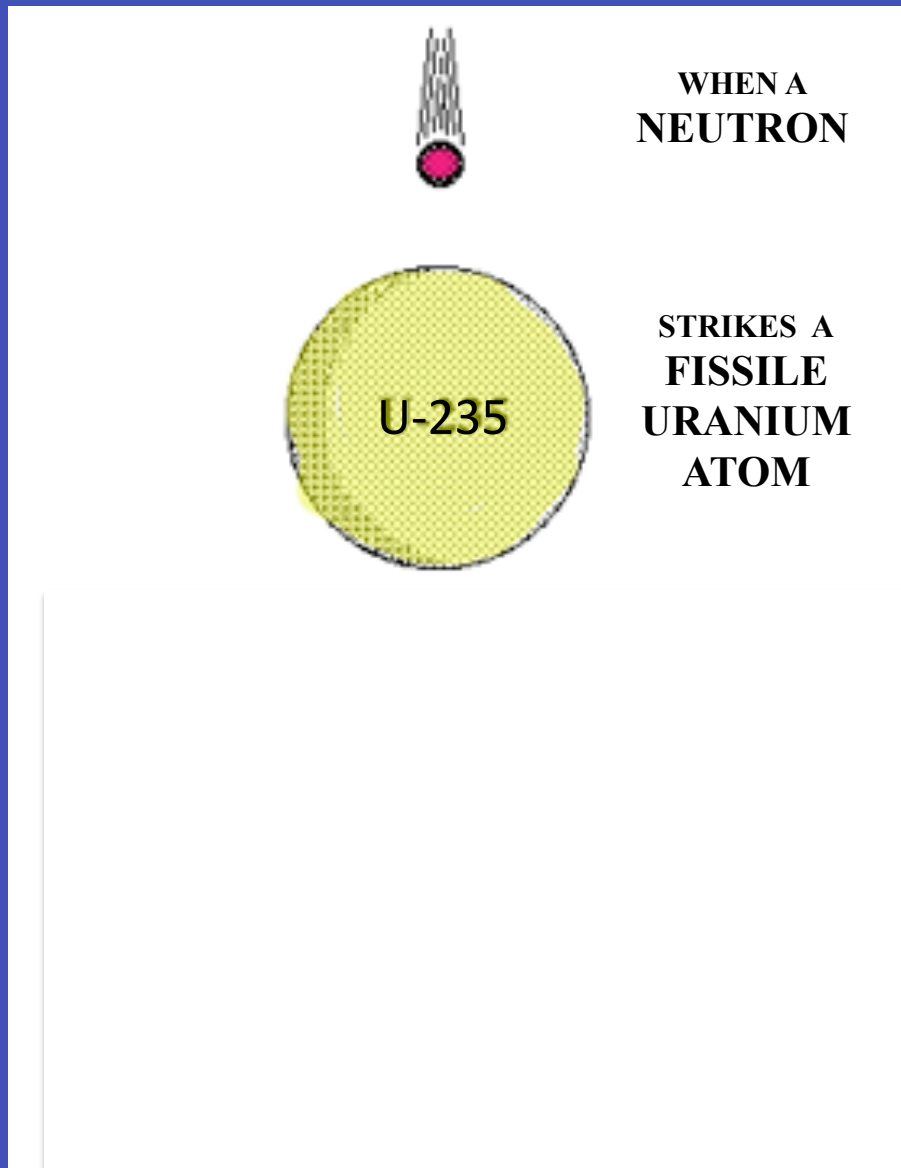
Nuclear Fission

How a PWR nuclear reactor works – Ringhals



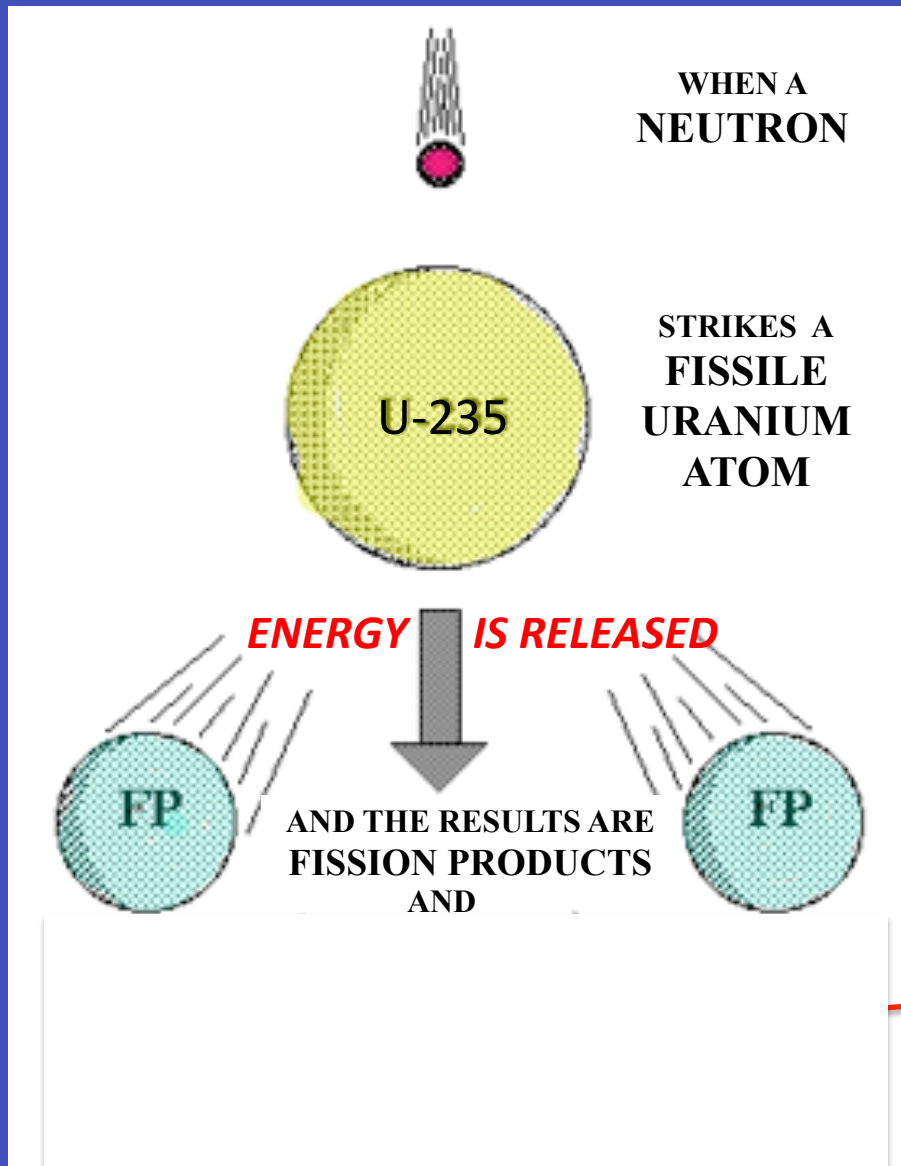
1. In the core, uranium atoms are split, releasing heat.
2. The heat boils water in vessels called steam generators
3. The steam is used to spin a turbine to generate electricity.
4. Meanwhile ***hundreds of unwanted radioactive byproducts are created.***

Nuclear Fission



A subatomic projectile called a neutron starts a **nuclear chain reaction** by splitting a nucleus of “fissile uranium” (U-235).

Nuclear Fission

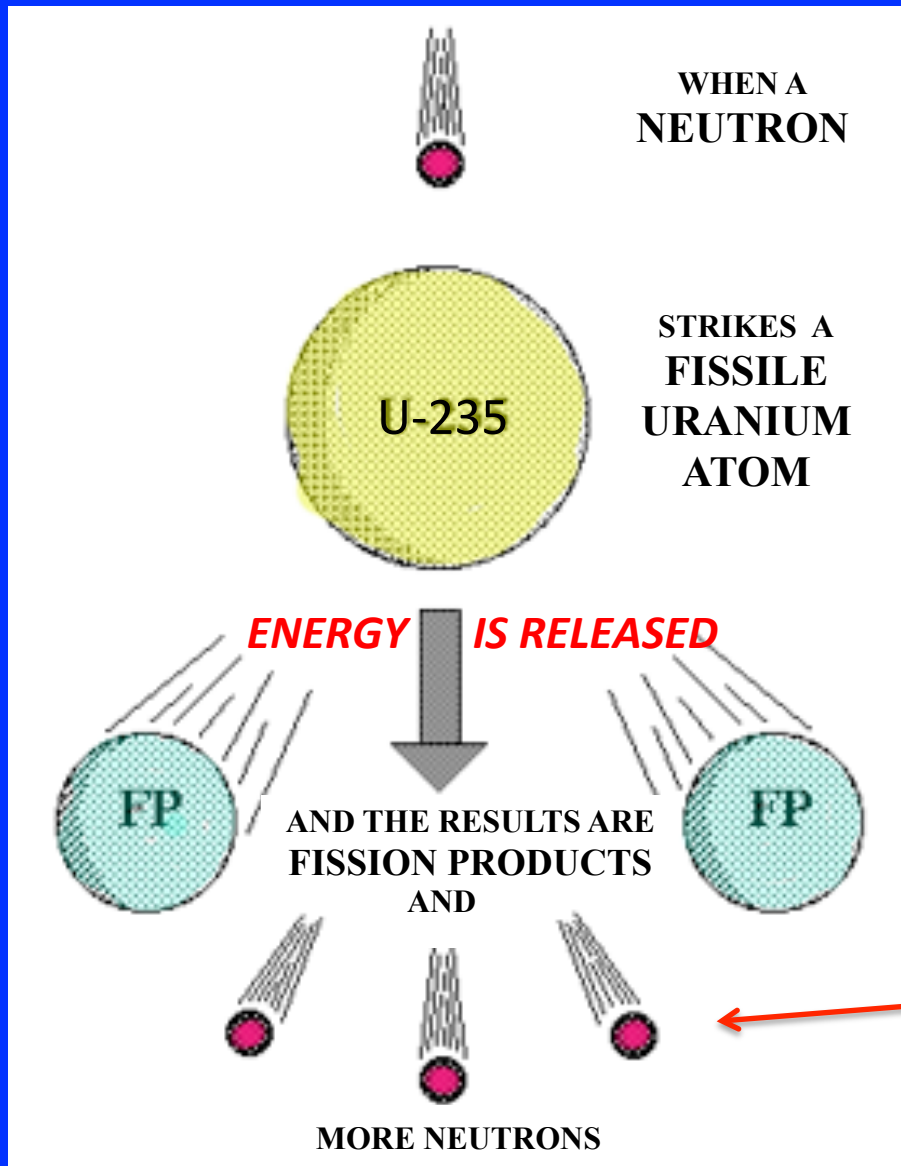


A subatomic projectile called a neutron starts a **nuclear chain reaction** by splitting a nucleus of “fissile uranium” (U-235).

The nucleus splits into **two large fragments** and energy is released – along with **2 or 3 extra neutrons**.

The 2 broken pieces are **new radioactive nuclei** called “**fission products**”.

Nuclear Fission



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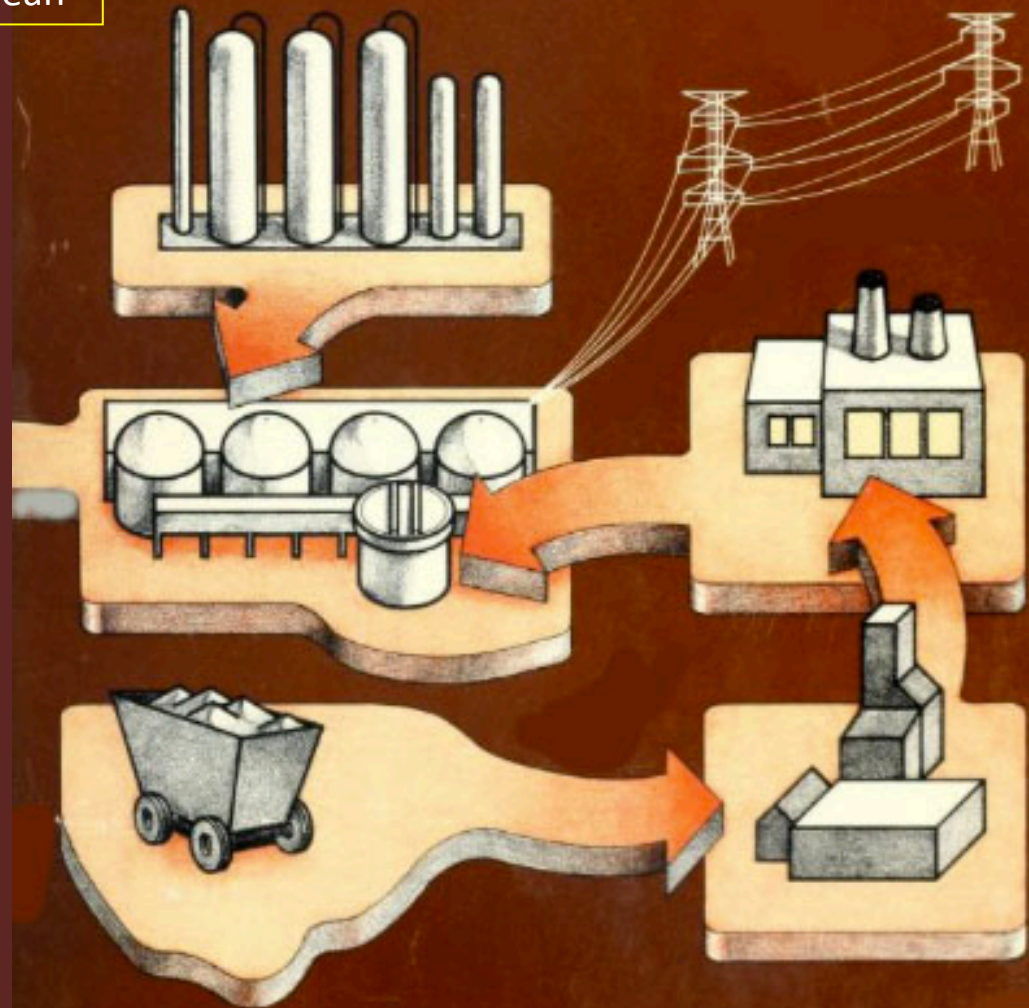
The nucleus splits into **two large fragments** and energy is released – along with **2 or 3 extra neutrons**.

The 2 broken pieces are **new radioactive nuclei** called “**fission products**”.

More neutrons trigger more fissions and some go on to produce even more radioactive wastes.

A Race Against Time

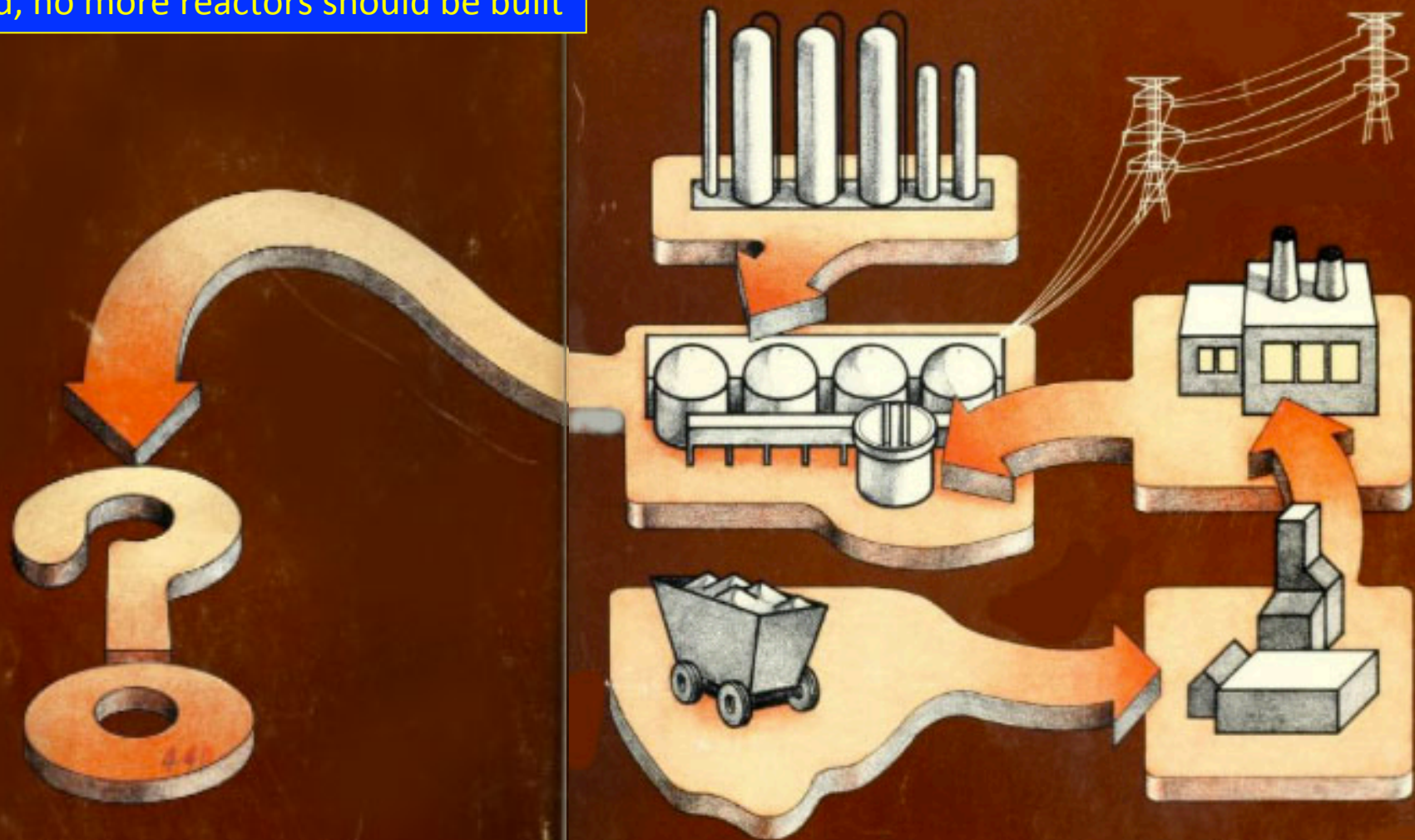
During the first 30 years of the nuclear age nuclear waste was unknown; nuclear was 'clean'



Royal Commission on Electric Power Planning

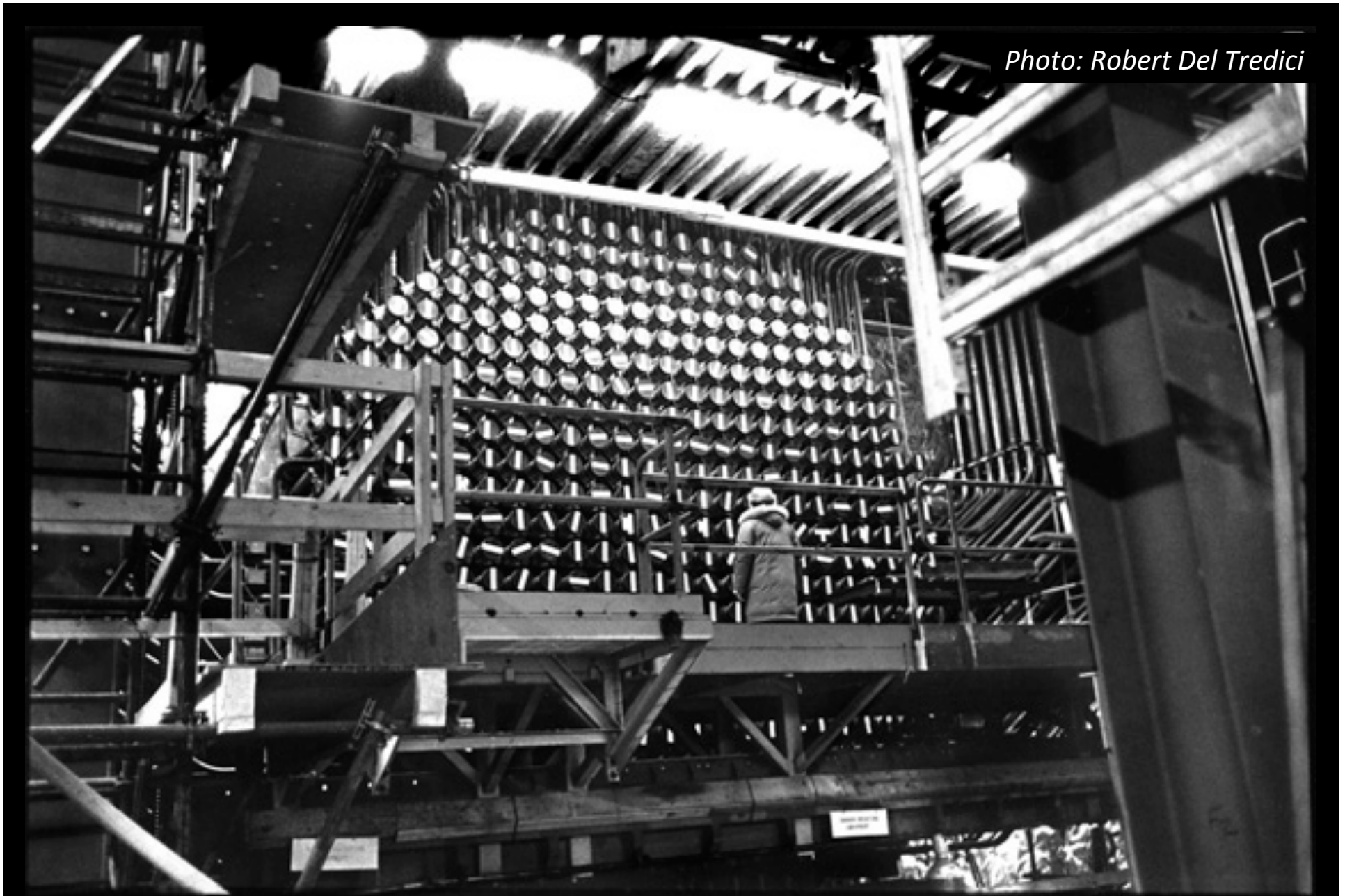
A Race Against Time

1978 : if nuclear waste problem is not solved, no more reactors should be built



Royal Commission on Electric Power Planning

Photo: Robert Del Tredici



Here is the **face of a CANDU reactor** loaded with fresh (unused) fuel bundles. If the shutdown reactor had ever operated **this man would be dead from gamma exposure.**

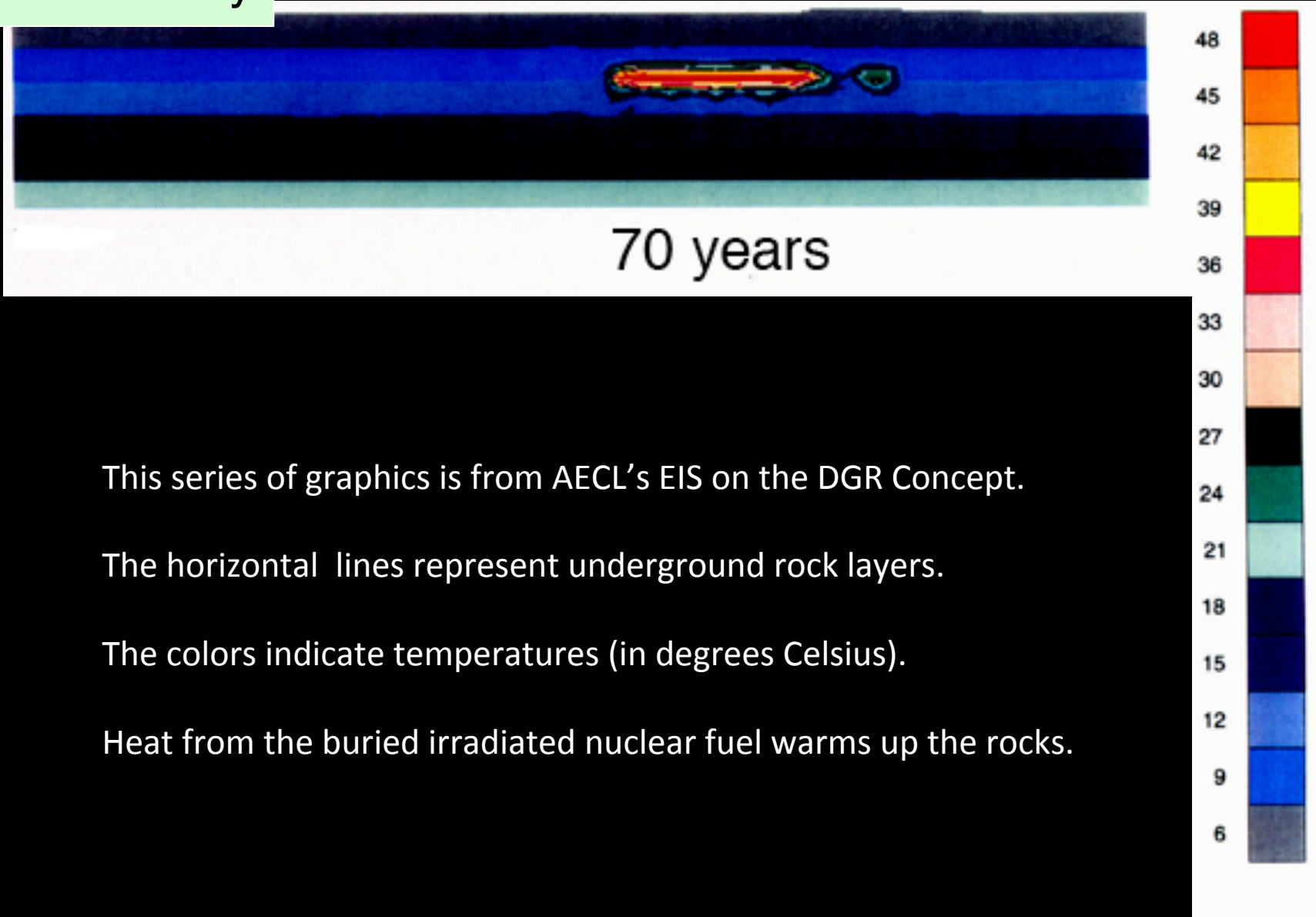
Radioactivity

Photo: Robert Del Tredici



Irradiated fuel must be cooled for years by **circulating water in a spent fuel pool**.

Radioactivity



This series of graphics is from AECL's EIS on the DGR Concept.

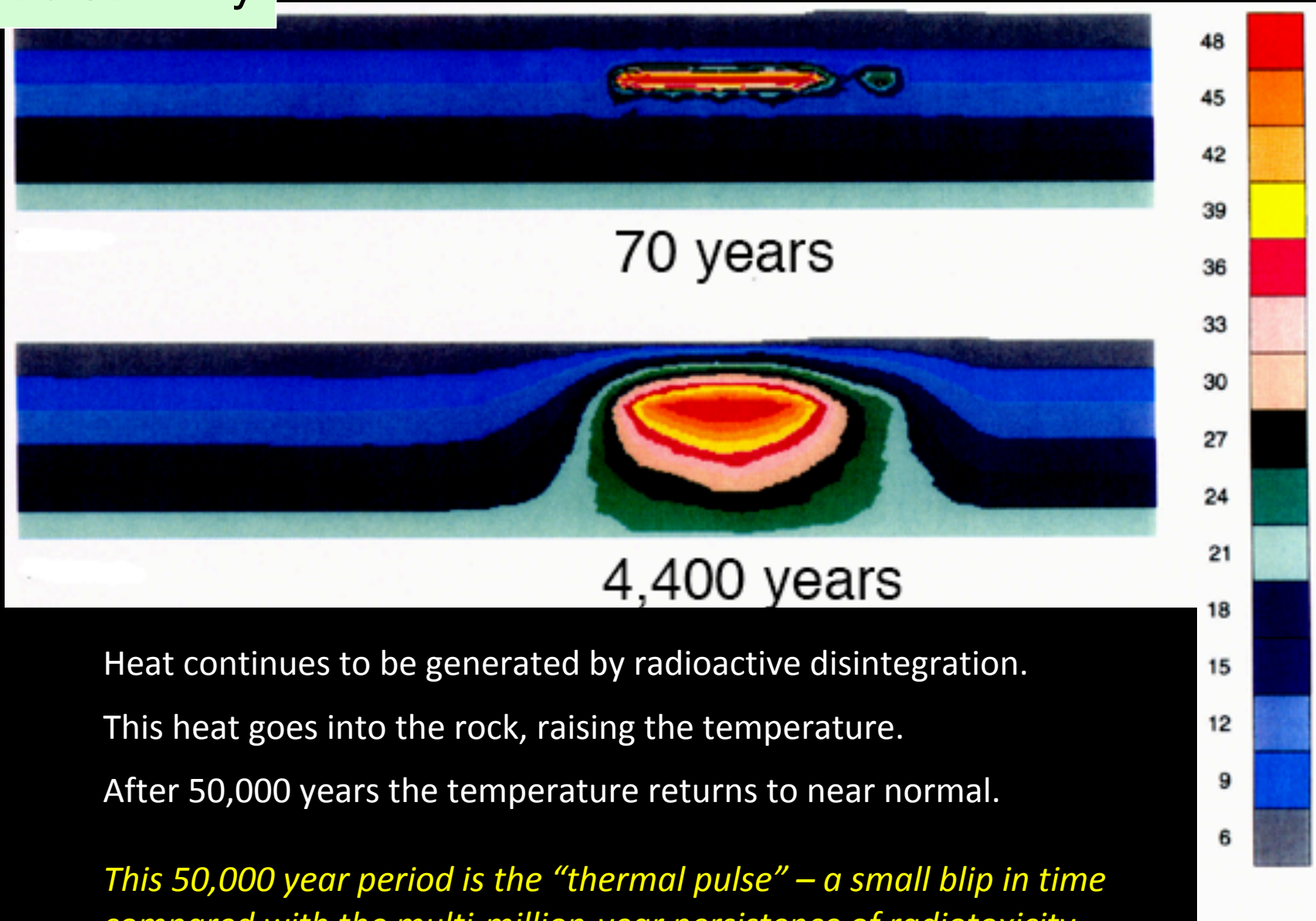
The horizontal lines represent underground rock layers.

The colors indicate temperatures (in degrees Celsius).

Heat from the buried irradiated nuclear fuel warms up the rocks.

from AECL's EIS on the Deep Geologic Disposal Concept, 1994.

Radioactivity



Heat continues to be generated by radioactive disintegration.

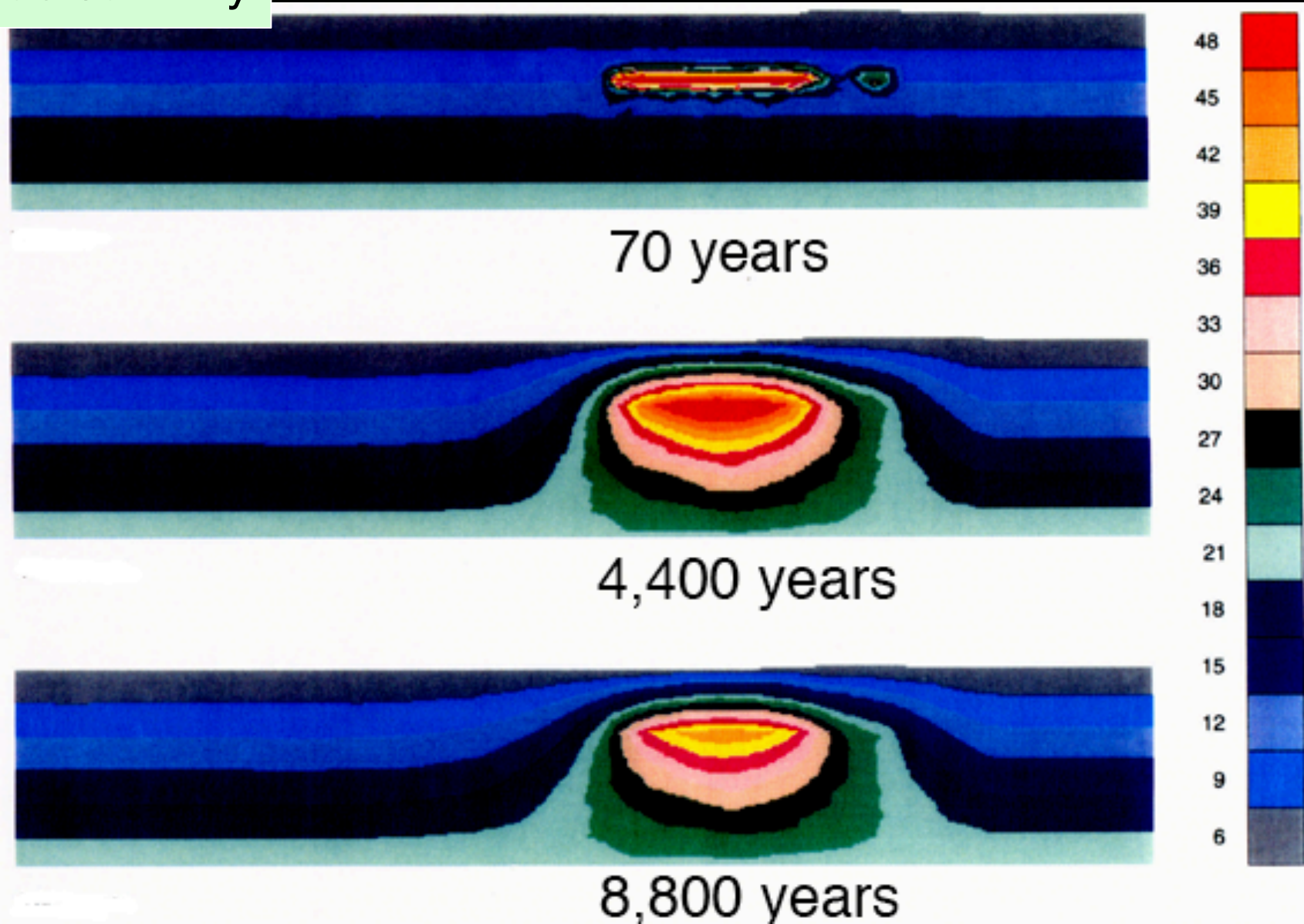
This heat goes into the rock, raising the temperature.

After 50,000 years the temperature returns to near normal.

This 50,000 year period is the “thermal pulse” – a small blip in time compared with the multi-million-year persistence of radiotoxicity.

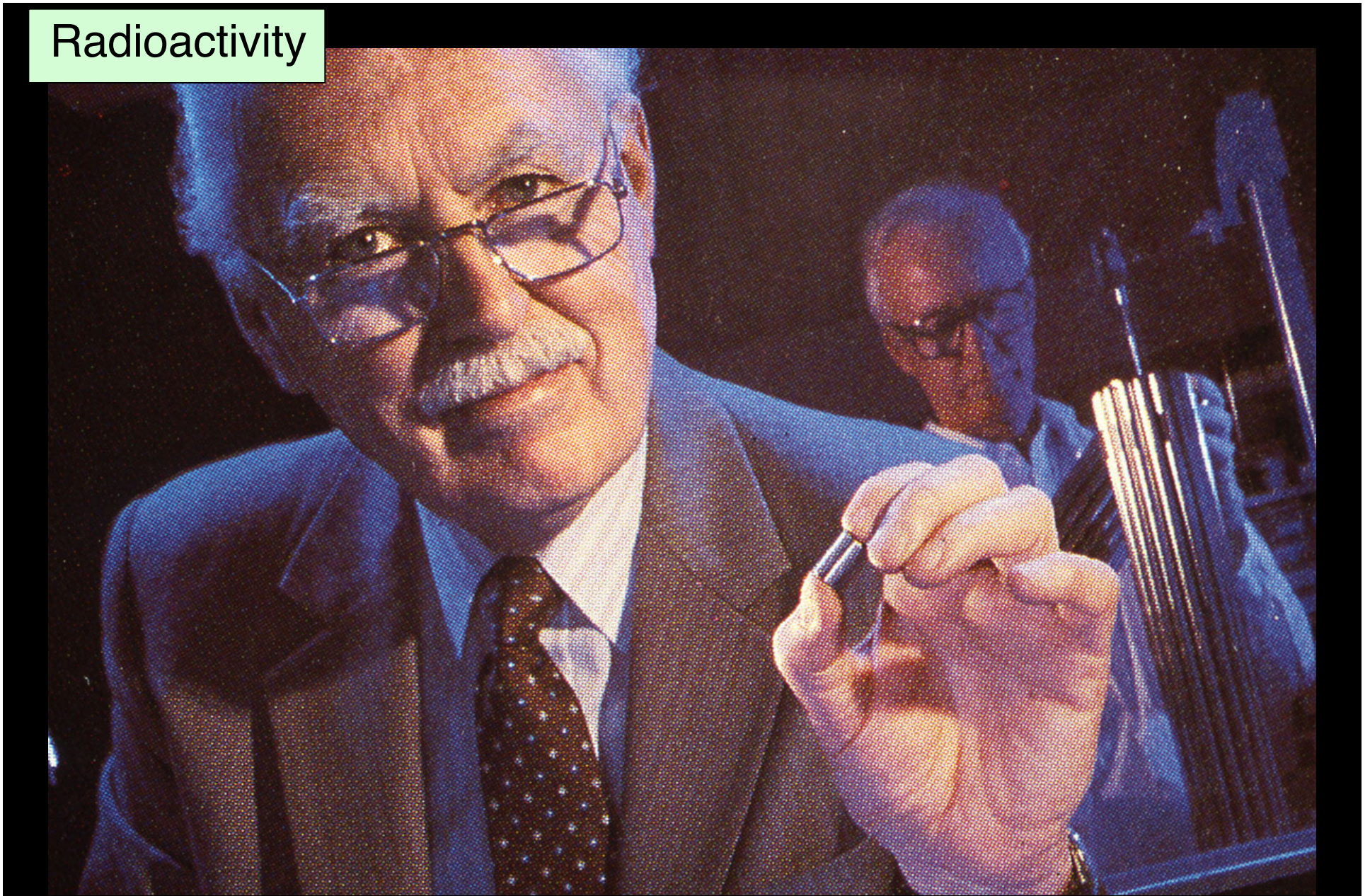
from AECL's EIS on the Geologic Disposal Concept, 1994.

Radioactivity



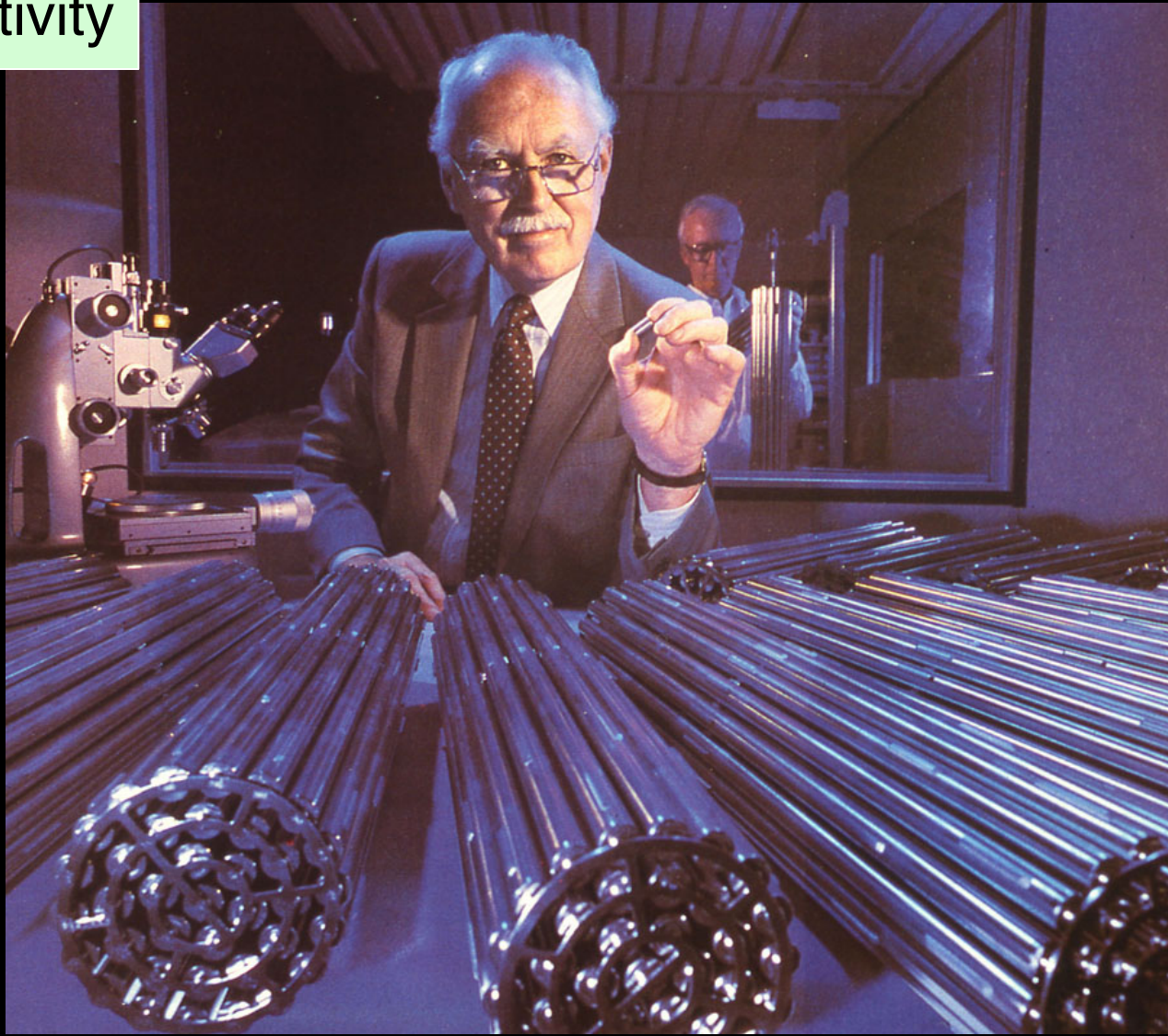
from AECL's EIS on the Geologic Disposal Concept, 1994.

Radioactivity



Canadian Nuclear Association ad: 'Small Wonder'

Radioactivity



Nuclear fuel rods and pellets can be handled safely before use,
Once used, the fission products will deliver a lethal dose of radiation in seconds.

"Small Wonder" : Canadian Nuclear Association Ad

What is Radioactivity?

a radioactive atom is unstable

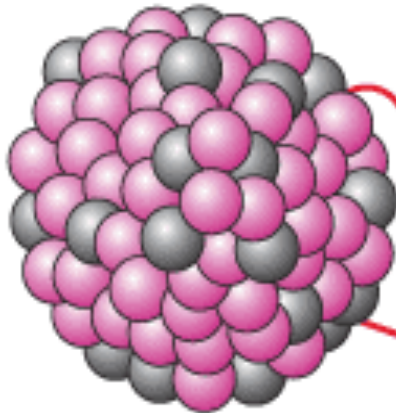
it will **disintegrate**

suddenly and violently

giving off “atomic radiation”

Radioactive Disintegration

Energy



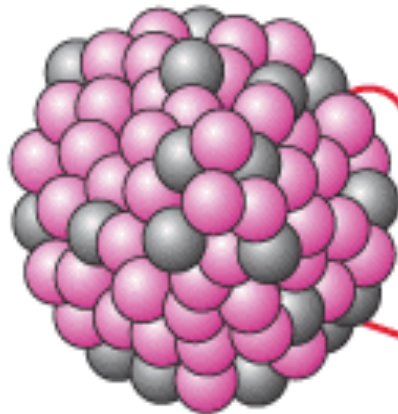
Atomic
Radiation

Radioactive
Nucleus

Particle

A radioactive atom has an unstable nucleus. It will **suddenly disintegrate**, giving off a highly energetic particle and/or a photon of energy. These emissions are **damaging to living cells**.

Three types of emissions: Alpha, Beta and Gamma



Radioactive Nucleus

(also called a radionuclide)

A radionuclide emits either **an alpha or a beta particle**. Such particles are electrically charged and move very fast. In some cases **a powerful gamma ray** is also given off. All three forms of atomic radiation damage living cells.

gamma
(sometimes)

alpha
or
beta
(always)

Energy

Atomic Radiation

Particle

(sometimes a neutron)

Radioactivity

Alpha, Beta, and Gamma “rays” are normally invisible

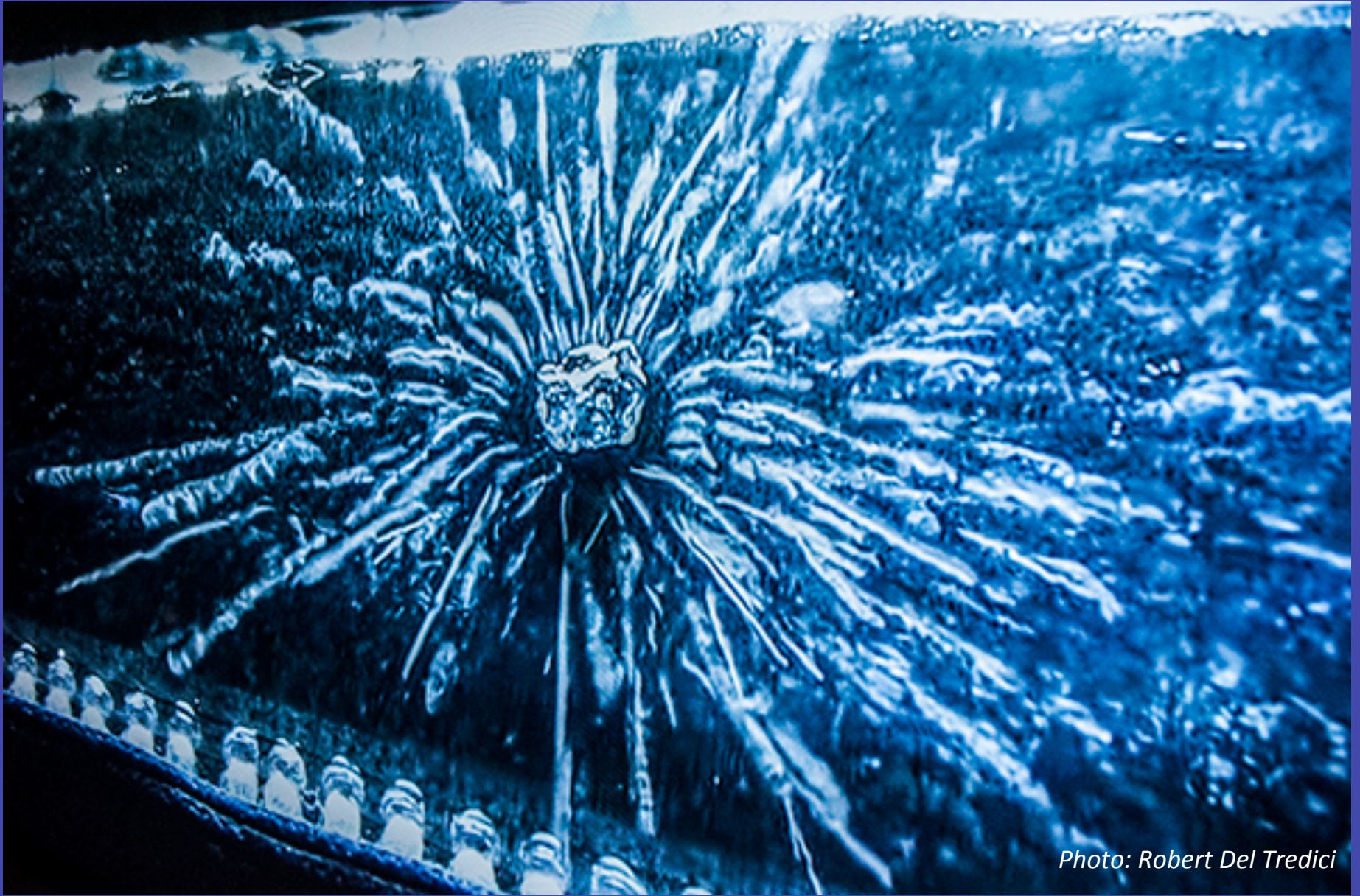


Photo: Robert Del Tredici

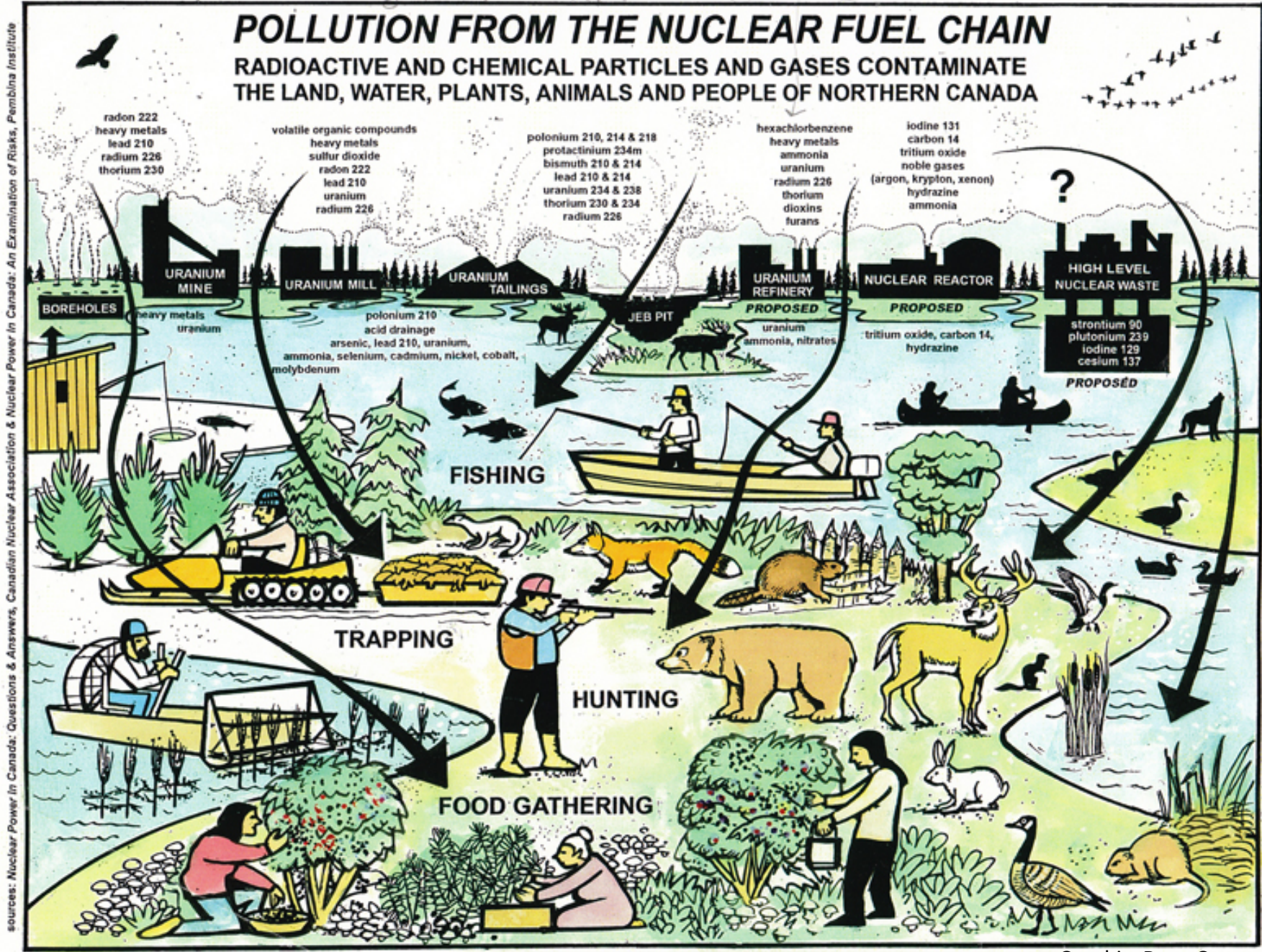
But in a “cloud chamber” you can see the tracks of all 3 types of emissions from uranium ore

Radioactivity is
a form of nuclear energy
that cannot be shut off.

*That's why we have
a nuclear waste problem.*

POLLUTION FROM THE NUCLEAR FUEL CHAIN

RADIOACTIVE AND CHEMICAL PARTICLES AND GASES CONTAMINATE THE LAND, WATER, PLANTS, ANIMALS AND PEOPLE OF NORTHERN CANADA



sources: Nuclear Power in Canada: Questions & Answers, Canadian Nuclear Association & Nuclear Power in Canada: An Examination of Risks, Pembina Institute

graphic: Coalition for a Clean Saskatchewan design group cleangreensask@yahoo.ca

ARROWS SHOW GENERALIZED EXPOSURE PATHWAYS THROUGH AIR & WATER

Graphic: Dave Geary

Radioactivity

All radioactive materials
are damaging to nearby living cells

*That's why nuclear waste
is a public health problem.*

RADIOACTIVE MATERIALS

THYROID

iodine-131
beta (gamma) ; 8 days

SKIN

sulphur-35
beta ; 87 days

LIVER

cobalt-60
beta (gamma) ; 5 years

OVARIES

iodine-131
beta (gamma) ; 8 days

cobalt-60
beta (gamma) ; 5 years

krypton-85
gamma ; 10 years

ruthenium-106
gamma ; 1 year

zinc-65
gamma ; 245 days

barium-140
gamma ; 13 days

potassium-42
gamma ; 12 hours

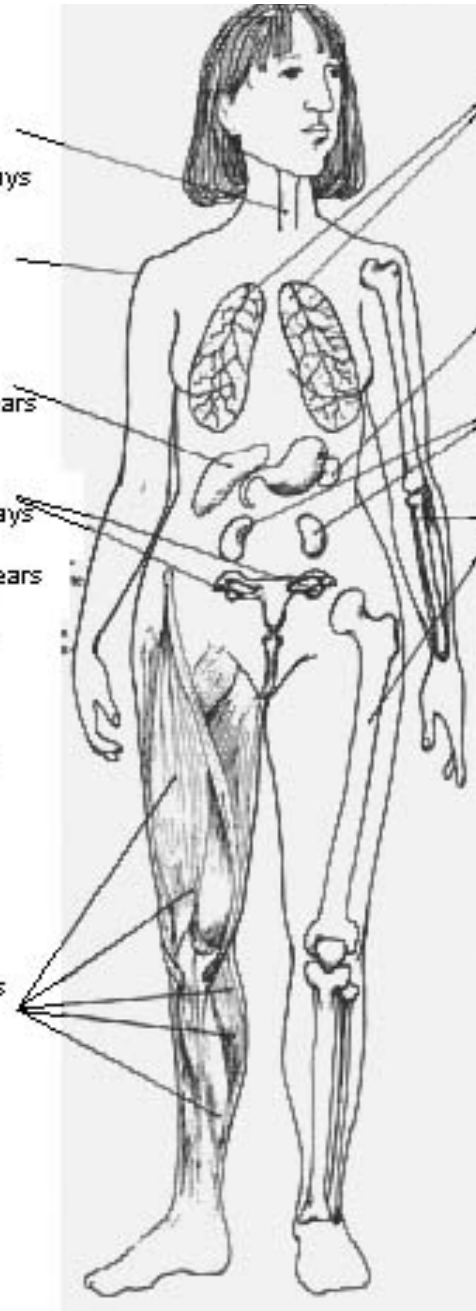
cesium-137
gamma ; 30 years

plutonium-239
alpha ; 24 000 years

MUSCLE

potassium-42
gamma ; 12 hours

cesium-137
gamma ; 30 years



LUNGS

radon-222 (and whole body)
alpha ; 3,8 days
uranium-233 (et os)
alpha ; 162 000 years
plutonium-239 (and bone)
alpha ; 24 000 years

SPLEEN

polonium-210 (and whole body)
alpha ; 138 days

KIDNEYS

uranium-238 (and bone)
alpha ; 4 500 000 years
ruthenium-106
gamma (beta) ; 1 year

BONE

radium-226
alpha ; 1 620 years

zinc-65
gamma ; 245 days

strontium-90
beta ; 28 years

yttrium-90
beta ; 64 hours

promethium-147
beta ; 2 years

barium-140
beta (gamma) ; 13 days

thorium-234
beta ; 24,1 days

phosphorus-32
beta ; 14 days

carbon-14 (and fat)
beta ; 5 600 years

Radioactive materials are chemical substances which are also radioactive.

Radioactivity

Chronic exposure to radioactive materials increases the incidence of cancer, leukemia, genetic damage, anemia, damaged immune systems, strokes, heart attacks, & low intelligence

There is a “latency period” for exposure at low levels –

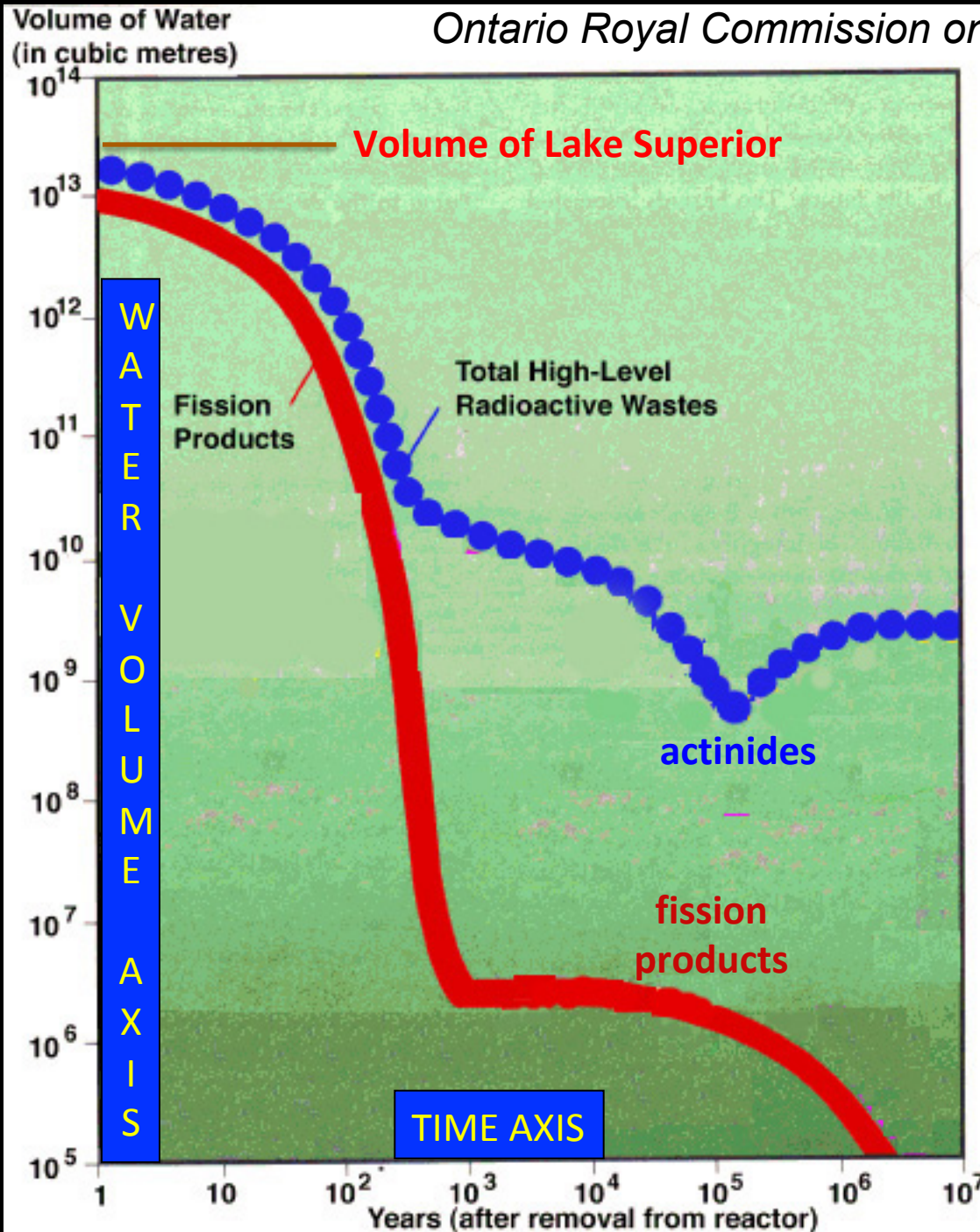
– the onset of disease may occur years or decades after exposure.

IRRADIATED NUCLEAR FUEL

Radiotoxicity

(10 million years and counting)

Ontario Royal Commission on Electric Power Planning (1978)

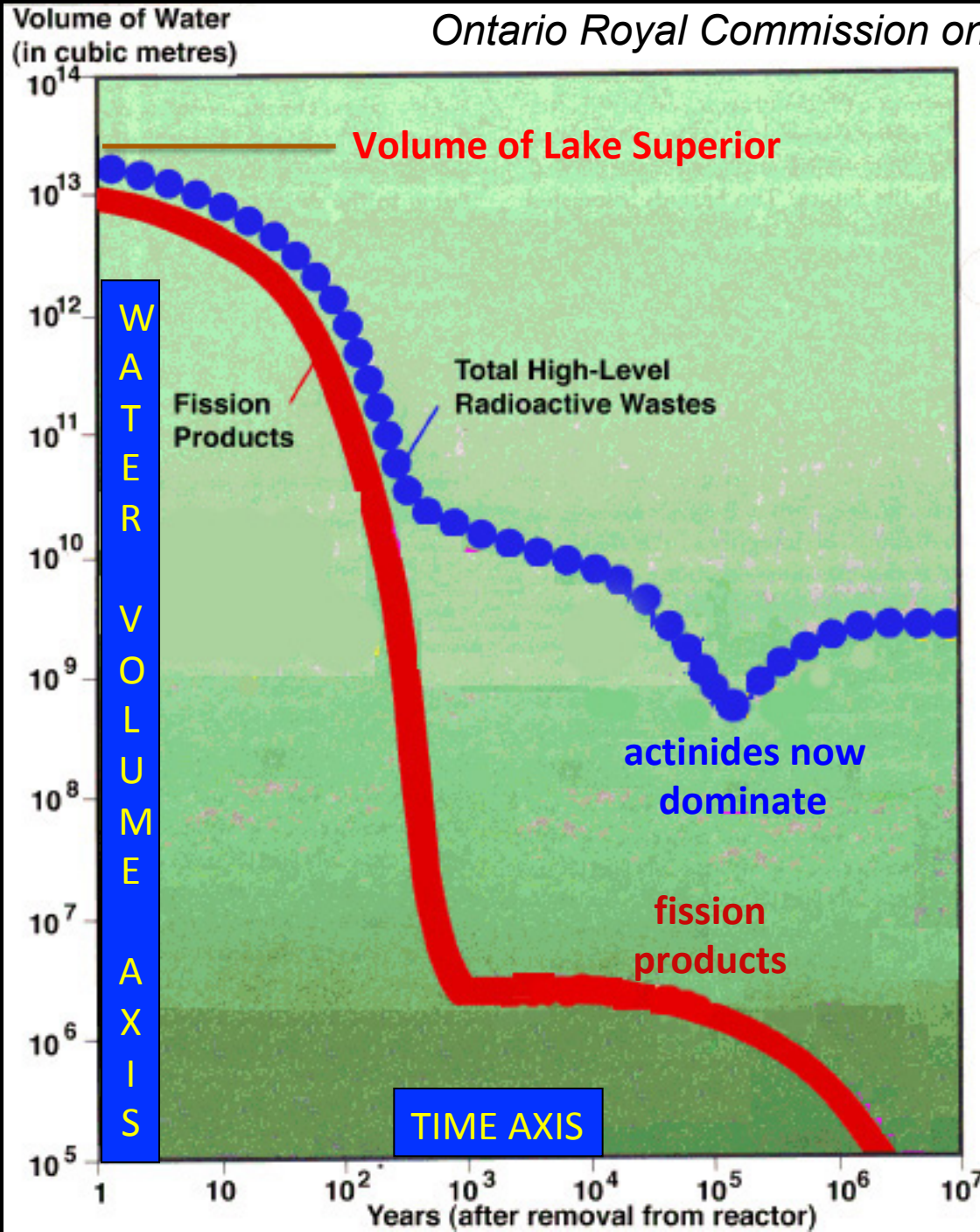


This graph shows the radiotoxicity of one year's worth of spent CANDU fuel from one reactor over a period of ten million years

The minimum amount of water needed to dilute (to drinking water legal limits) one year of "fresh" spent fuel just out of a CANDU reactor is about equal to the volume of Lake Superior.

Royal Commission Report, 1978

Ontario Royal Commission on Electric Power Planning (1978)



For the first 500 – 1000 years, fission products are the deadliest components of nuclear fuel waste.

After 1000 years, actinides are the deadliest components of nuclear fuel waste.

What is an Actinide?

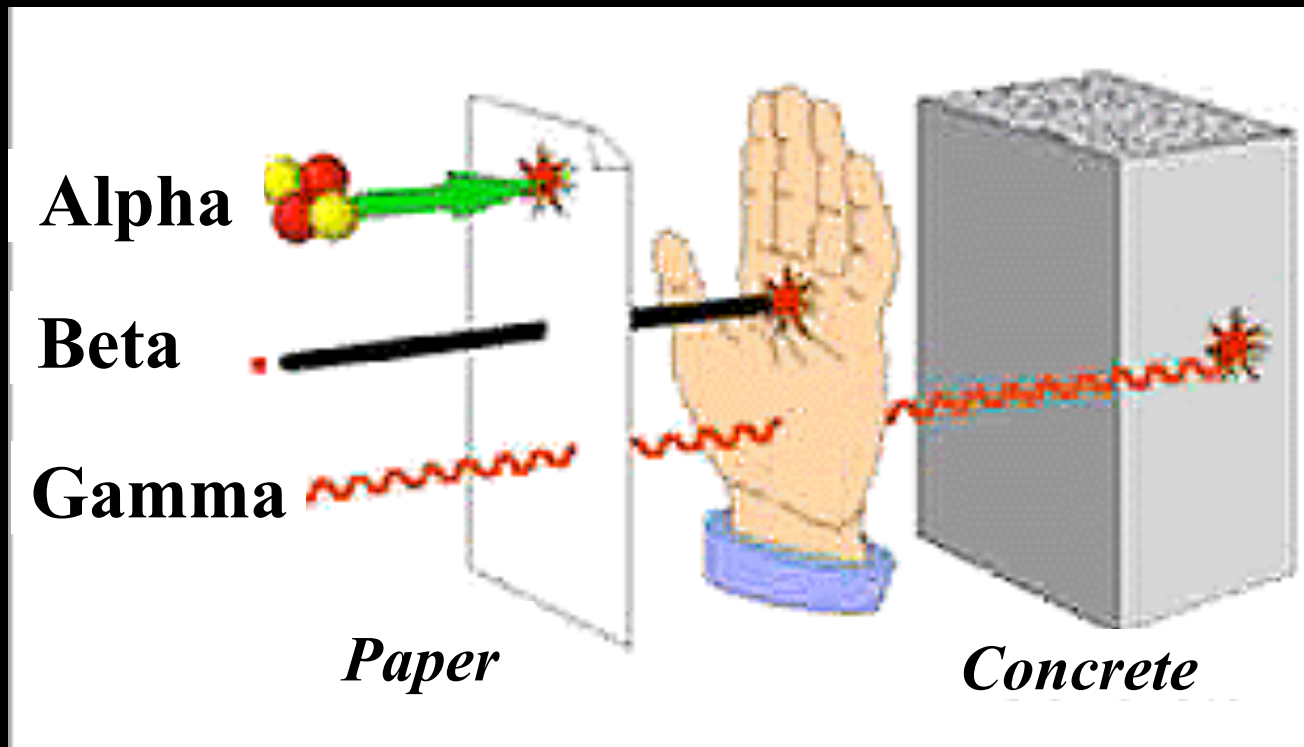
Actinides are very heavy elements. They include **uranium, thorium, and the transuranic elements**. ALL actinides are radioactive and highly dangerous.

Most actinides are “alpha-emitters”. Alpha radiation is harmless outside the body, but **extraordinarily damaging when inhaled, absorbed, or ingested**.

Unlike most fission products, the heavier actinides typically have **half-lives measured in tens of thousands of years, or even millions of years**.

Most actinides are alpha-emitting radioactive materials

Alpha particles can be stopped by a sheet of paper.
Alpha emitters are harmless outside the body, but much more damaging than beta or gamma when ingested or inhaled.



Beta particles penetrate only part-way.
They can damage *eyes or skin* externally
but the *main danger is internal exposure*.

Gamma rays are highly penetrating.
They give "*whole body*" radiation.
Heavy *shielding* is often needed.

This photo shows a tiny speck of plutonium lodged in lung tissue.

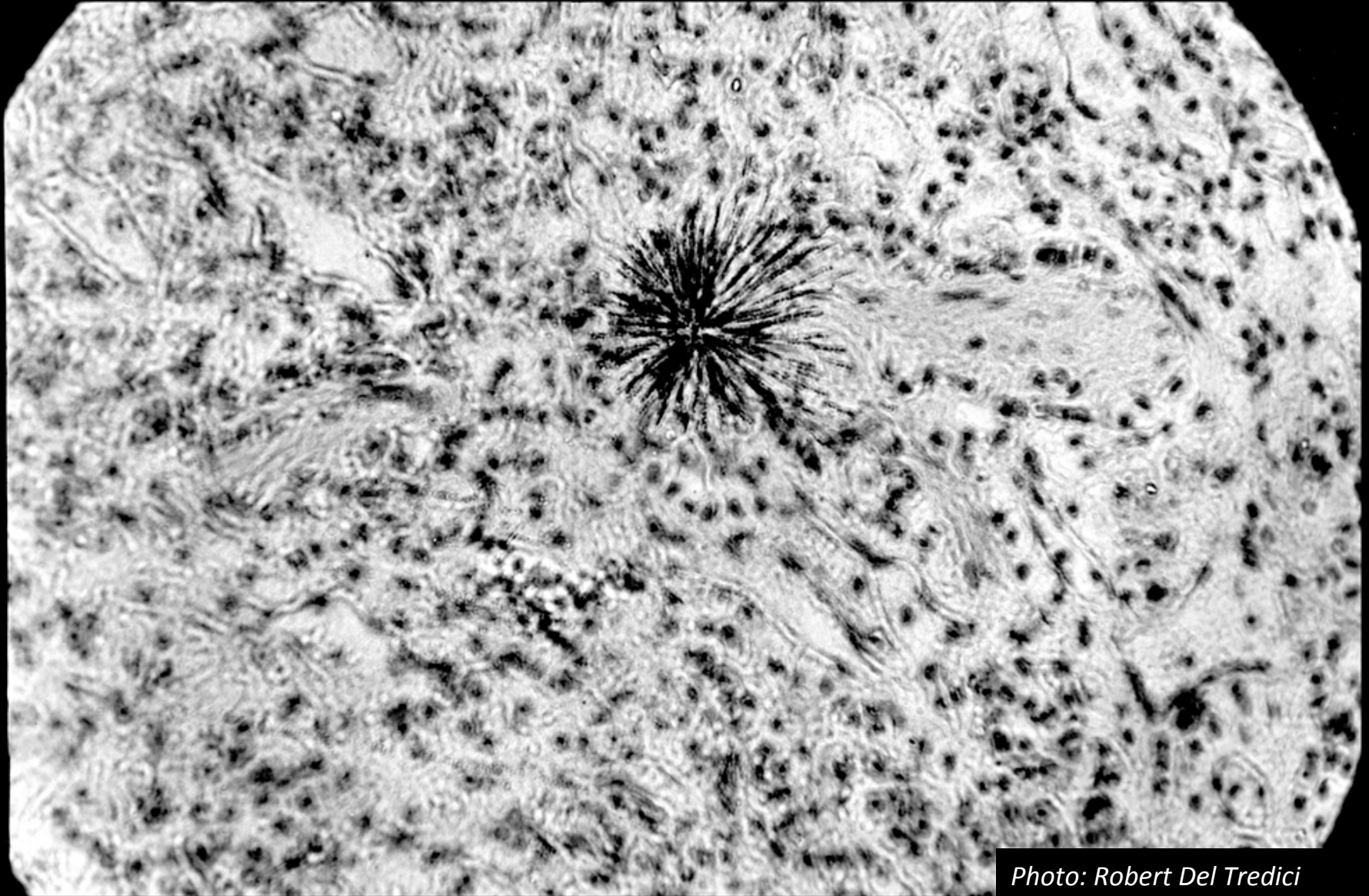


Photo: Robert Del Tredici

The “spikes” are the tracks of alpha particles emitted over 48 hours.

The lung tissue of an experimental animal seen through a microscope over a period of 48 hours. At the centre of the “star” is a tiny radioactive particle of plutonium.

Photo: Robert Del Tredici

Each “spike” is the track of an alpha particle given off during that 48 hour period. These radioactive emissions do not travel very far.

But some of the cells that are damaged may be able to reproduce with defective genes – these cells could be the beginning of cancer.

radium, radon, polonium, thorium, plutonium, uranium – all alpha emitters.

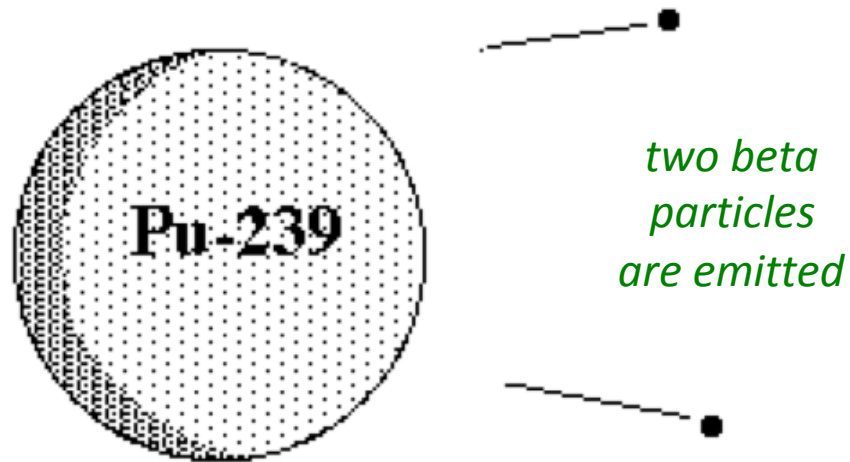
Radioactivity

Creation of plutonium inside a nuclear reactor ...



... when an atom of uranium-238 absorbs a neutron

Radioactivity



. . . it is transformed into an atom of plutonium-239

Other transuranic actinides are produced in a similar way.



This glass paperweight is the exact size of the plutonium ball that was used as a nuclear explosive in the Nagasaki bomb.

Photo: Robert Del Tredici

Two Monumental Untruths

Untruth #1
(1945-1975)

*Nuclear energy is clean – there's no toxic waste.
Nuclear reactors are therefore safe.*

Untruth #2
(1975-present)

*We have a “permanent solution” to nuclear waste.
It is therefore safe to abandon it and forget it.*

FACTS:

There are 100s of radioactive poisons with distinct biological pathways.

We do not know how to destroy or neutralize these wastes.

Nuclear wastes are dangerous for millennia, even millions of years.

Disposal = abandonment: this approach is not scientific or ethical.

Lack of precedent: humans have never safely “disposed” of anything.

USA has tried 8 times to locate a disposal site and failed all 8 times.

Germany has two failed underground repositories: Asse II, Morsleben.

WIPP, the only Deep Geologic Repository in USA, recently failed.

Canada's NWMO

The **Seaborn Panel** recommended (1998) a Nuclear Fuel Waste Management Agency (NFWMA) that would

- *be at **arm's length** from the nuclear industry,*
- *have **stakeholders** on the Board of Directors, and*
- ***report regularly to the Parliament** of Canada.*

Instead, the **Government** created (2002) an **industry-owned** Nuclear Waste Management Organization (NWMO)

- *whose Board Members are representatives of the **nuclear waste producers**, and*
- *which reports to the **Minister of Natural Resources**,
– the one responsible for promoting nuclear power!*

Nuclear Waste Governance in Canada

Rolling Stewardship

Nuclear Waste Governance in Canada

Recently in Canada an alternative to the abandonment of reactor wastes has been proposed, based on the concept of “Rolling Stewardship”.

ANISHINABEK/IROQUOIS FIRST NATIONS

Joint Declaration *[May 2017]*

1. No Abandonment: Radioactive waste materials are damaging to living things. Many of these materials remain dangerous for tens of thousands of years or even longer. They must be kept out of the food we eat, the water we drink, the air we breathe, and the land we live on for many generations to come. The forces of Mother Earth are powerful and unpredictable and no human-made structures can be counted on to resist those forces forever. **Such dangerous materials cannot be abandoned and forgotten.**

2. Monitored and Retrievable Storage: Continuous guardianship of nuclear waste material is needed. This means long-term monitoring and retrievable storage. Information and resources must be passed on from one generation to the next so that our grandchildren's grandchildren will be able to detect any signs of leakage of radioactive waste materials and protect themselves. **They need to know how to fix such leaks as soon as they happen.**

3. Better Containment, More Packaging: Cost and profit must never be the basis for long-term radioactive waste management. Paying a higher price for better containment today will help prevent much greater costs in the future when containment fails. Such failure will include irreparable environmental damage and radiation-induced diseases. **The right kinds of packaging should be designed to make it easier to monitor, retrieve, and repackage** insecure portions of the waste inventory as needed, for centuries to come.

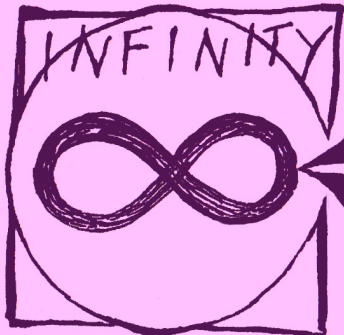
4. Away from Major Water Bodies: Rivers and lakes are the blood and the lungs of Mother Earth. When we contaminate our waterways, we are poisoning life itself. That is why **radioactive waste must not be stored beside major water bodies for the long-term.** Yet this is exactly what is being planned at five locations in Canada: Kincardine on Lake Huron, Port Hope near Lake Ontario, Pinawa beside the Winnipeg River, and Chalk River and Rolphton beside the Ottawa River.

5. No Imports or Exports: The import and export of nuclear wastes over public roads and bridges should be forbidden except in truly exceptional cases after full consultation with all whose lands and waters are being put at risk. In particular, the planned shipment of highly radioactive liquid from Chalk River to South Carolina should not be allowed because it can be down-blended and solidified on site at Chalk River. **Transport of nuclear waste should be strictly limited and decided on a case-by-case basis with full consultation with all those affected.**

ABANDONMENT

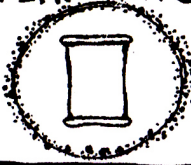
FOREVER ← LATER ← NOW ← NUCLEAR WASTES

Into Eternity...



NO TRANSPARENCY
NO EDUCATION
NO CONSULTATION
NO ALTERNATIVES
NO REMEDIATION
... nobody home

LONG TERM
PLANNING

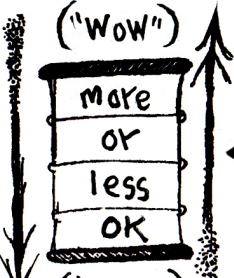


STAGING PLATFORM
for INFINITY

licence
to abandon

SHORT TERM

("wow")

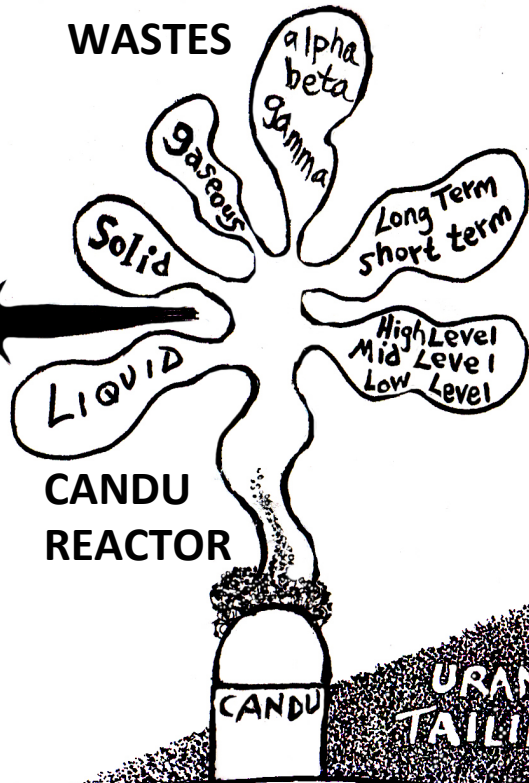


more
or
less
OK

("oops")

TRANSPARENCY
EDUCATION
CONSULTATION
ALTERNATIVES
REMEDATION

NUCLEAR
WASTES

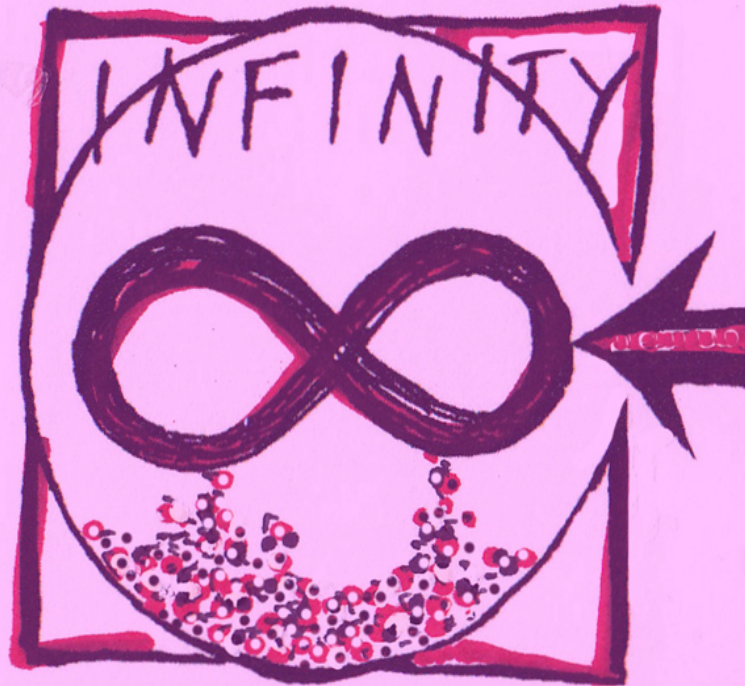


CANDU
REACTOR

URANIUM
TAILINGS

leading to *amnesia* ...

Into Eternity...



NO TRANSPARENCY
NO EDUCATION
NO CONSULTATION
NO ALTERNATIVES
NO REMEDIATION

... nobody home

after
abandonment ...

... amnesia
sets in !

PROPOSAL:

A new nuclear waste policy based on frankness.

We begin by admitting we have at present no proven solution.

The alternative to abandonment is Rolling Stewardship.

Wastes are monitored and retrievable for the foreseeable future.

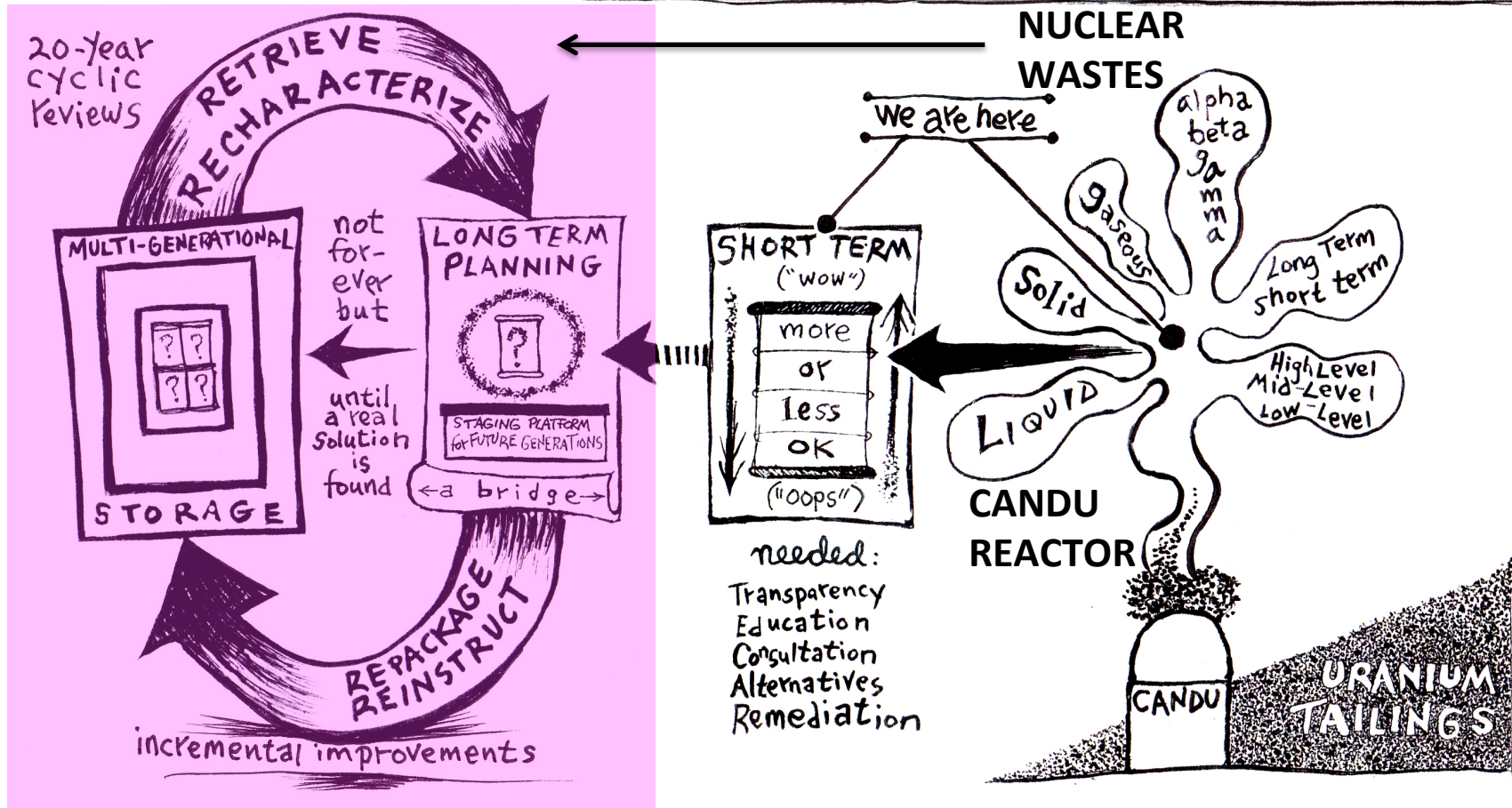
Wastes are packaged safely for extended periods & repackaged later.

This is not a solution – it is only an ethical waste management scheme.

Rolling Stewardship is needed until a “genuine solution” is found.

The production of additional nuclear wastes can/should be stopped.

ROLLING STEWARDSHIP

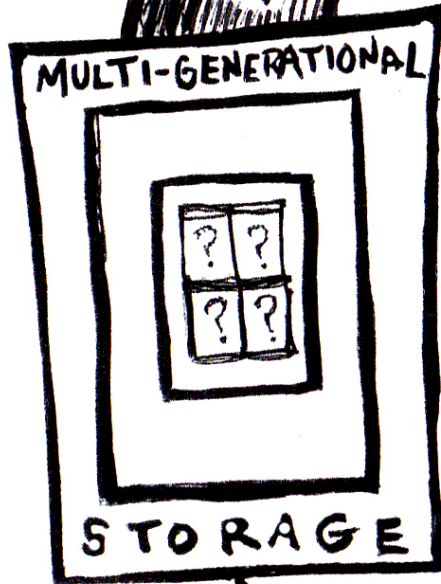


PERSISTENCE of MEMORY

Future generations have an incentive to find a genuine solution

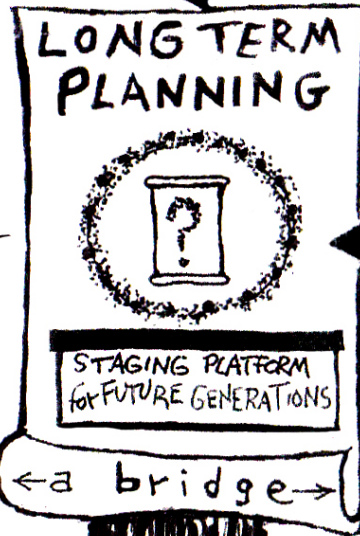
20-year
cyclic
Reviews

RETRIEVE
RECHARACTERIZE



not
for-
ever
but

until
a real
solution
is
found

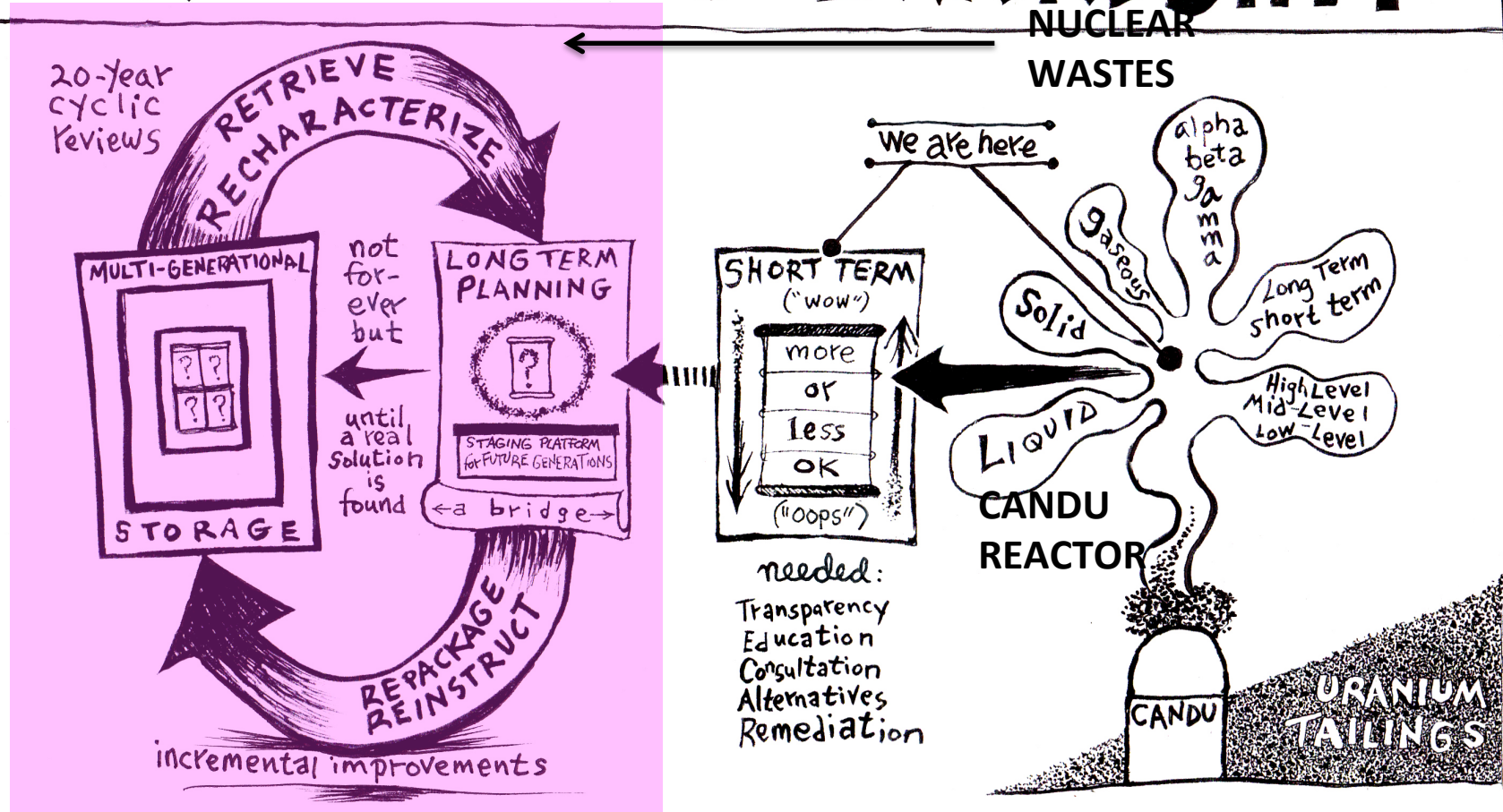


REPACKAGE
REINSTRUCT

incremental improvements

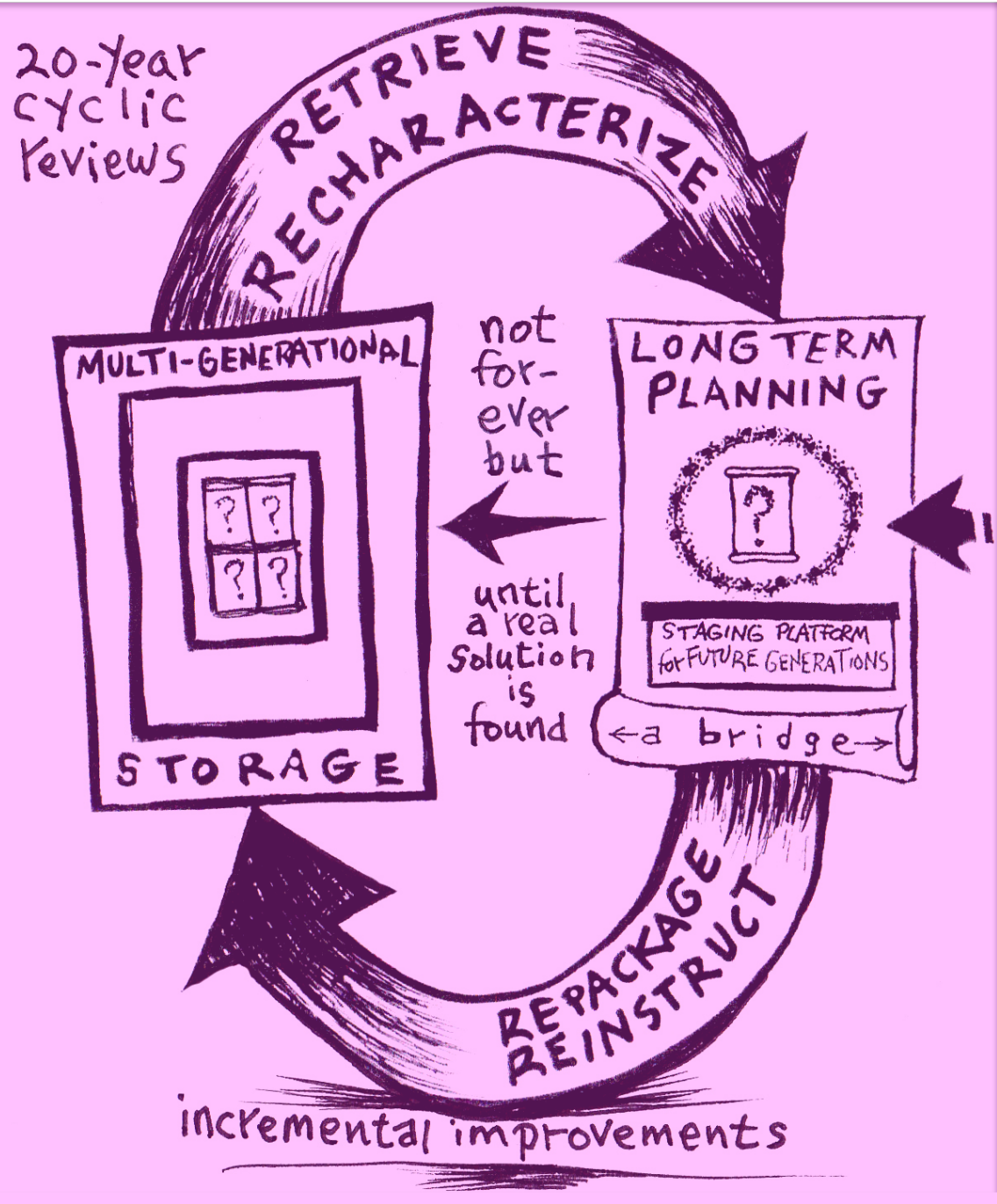
Rolling Stewardship is continuous; it is based on ensuring Persistence of Memory

ROLLING STEWARDSHIP



PERSISTENCE of MEMORY

Future generations have an incentive to find a genuine solution

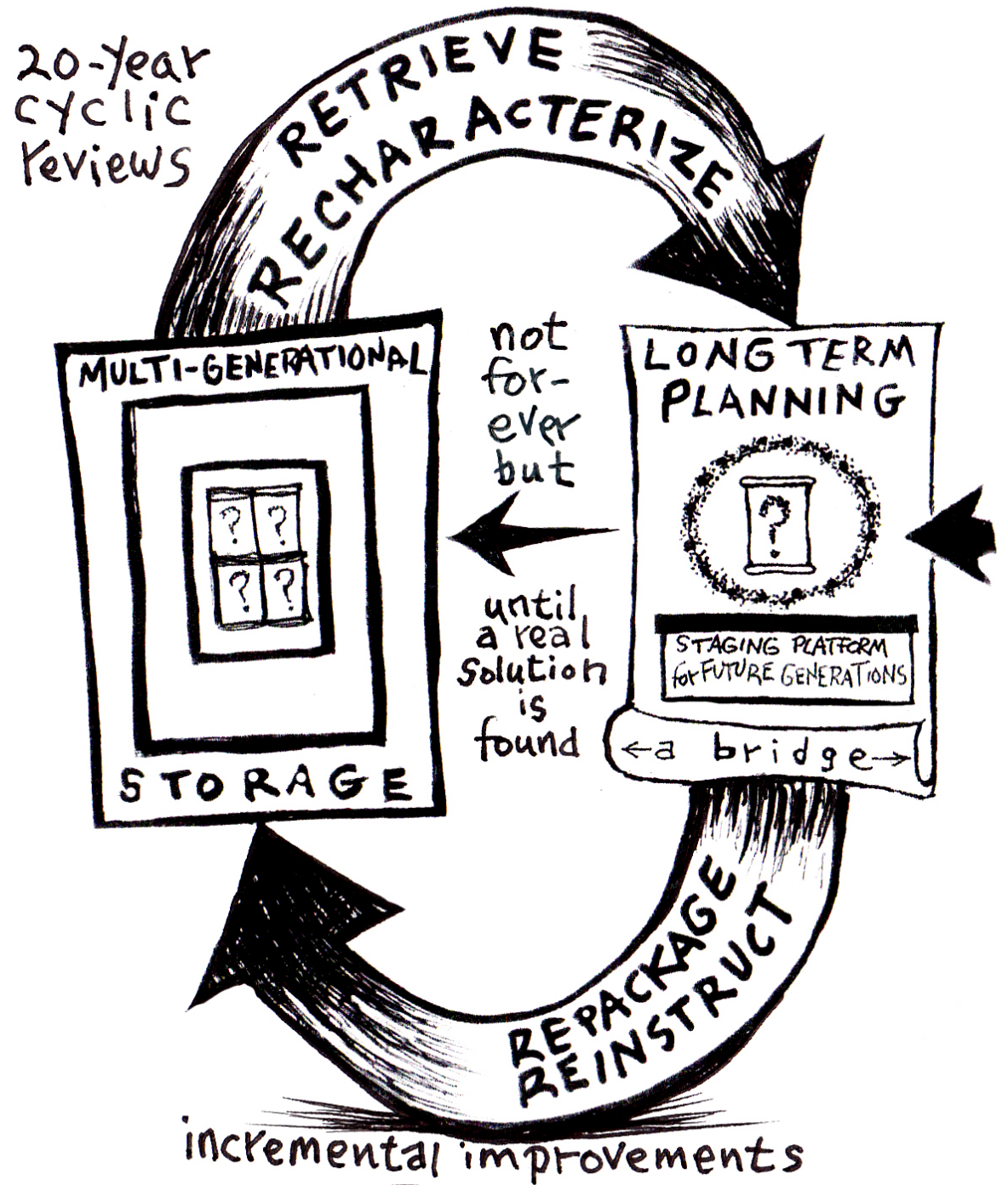


Rolling Stewardship is an **intergenerational** management strategy

With a “changing of the guard” **every 20 years the necessary knowledge and resources can be communicated** to the next generation.

Those in charge must be **independent** of the nuclear industry.

ROLLING STEWARDSHIP



These young Chelyabinsk women have just learned that **high-level liquid waste was dumped into the Techa River that flows past their village, decades ago**, explaining a rash of diseases since.



Photo: Robert Del Tredici

We must all make our best efforts to ensure that radioactive wastes **do not contaminate the air we breathe, the food we eat, the water we drink, or our reproductive cells.**

The End

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