

Lessons from Fukushima

Remediation Efforts in Contaminated Areas

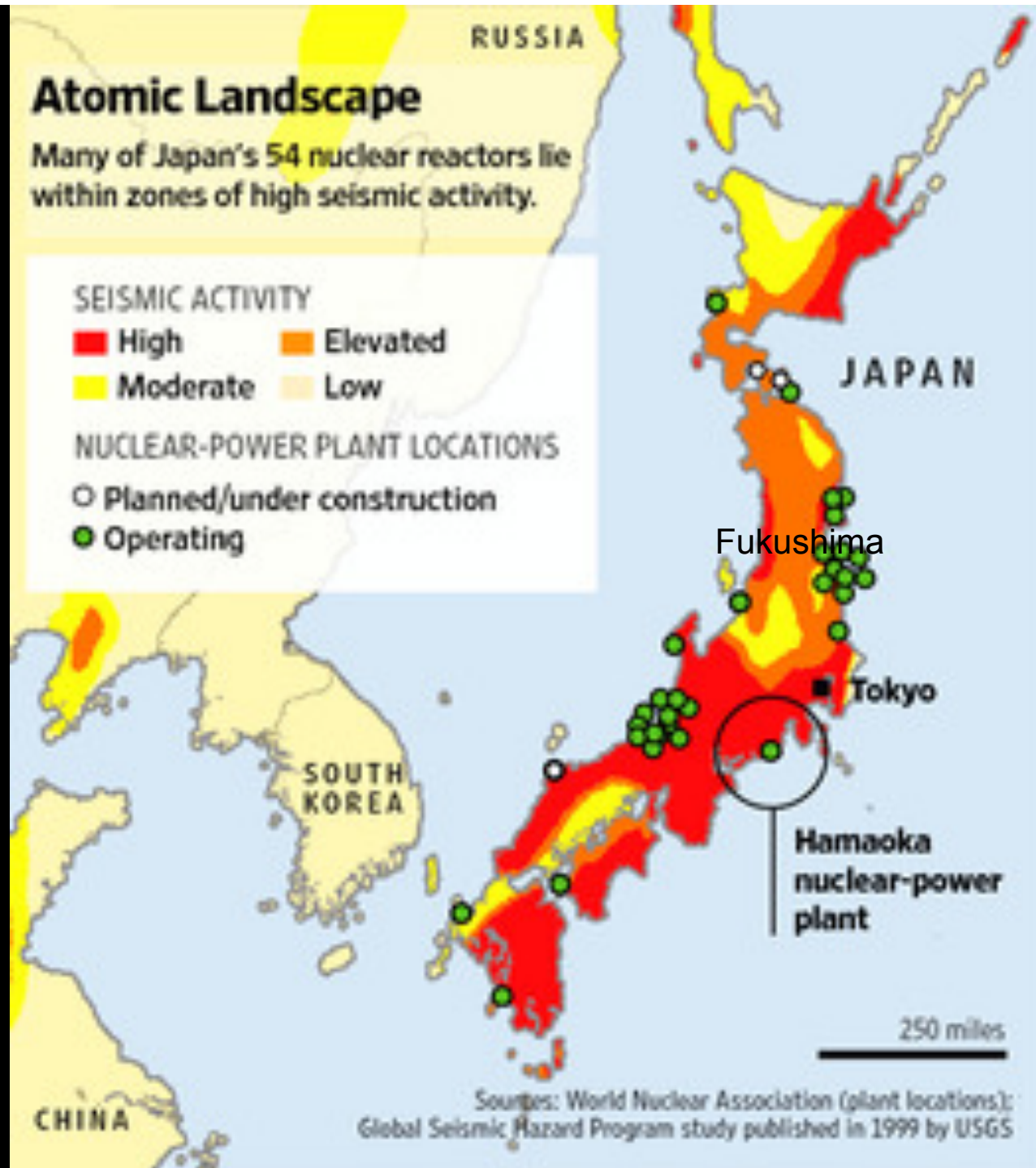
A Slide Show Presentation by
Gordon Edwards Ph.D.
CCNR@WEB.CA

Featuring the B&W photos of
Robert Del Tredici

March 5 2014

When the 2011 earthquake hit, Japan had 54 reactors. Today none of them are operating.

This 1995 map shows that the Fukushima Daiichi reactors are not sited in the riskiest part of Japan for earthquakes.



Unit 1-4 reactors at Fukushima before – and after – the earthquake & tsunami



There was no visible damage done to the reactors by the earthquake or tsunami

Two days after the tsunami the reactors started exploding – four of them !



The damage is all self-inflicted; the reactors did it to themselves !



The radioactive waste inside the reactor core is what caused the damage. The reactors themselves were shut down, but you can't shut off radioactivity.



This is a model of the uranium atom (at Oak Ridge, Tennessee).

Uranium is the key element of all nuclear technology, whether military or civilian.

When atoms of uranium are split, enormous energy is released.



A soviet monument to the splitting of the atom. The semicircles symbolize energy. The two hemispheres represent "fission products" - broken pieces of uranium atoms.



What is a Meltdown?

Fission products produce **decay heat** due to radioactivity

Decay Heat **cannot be shut off** – it has to be removed (pumps)

Loss of power after shutdown results in **rising temperatures**

At 1800 degrees C, **cladding 'burns'** and releases hydrogen gas

At 2800 degrees C, the **ceramic fuel melts**

Chain of Events

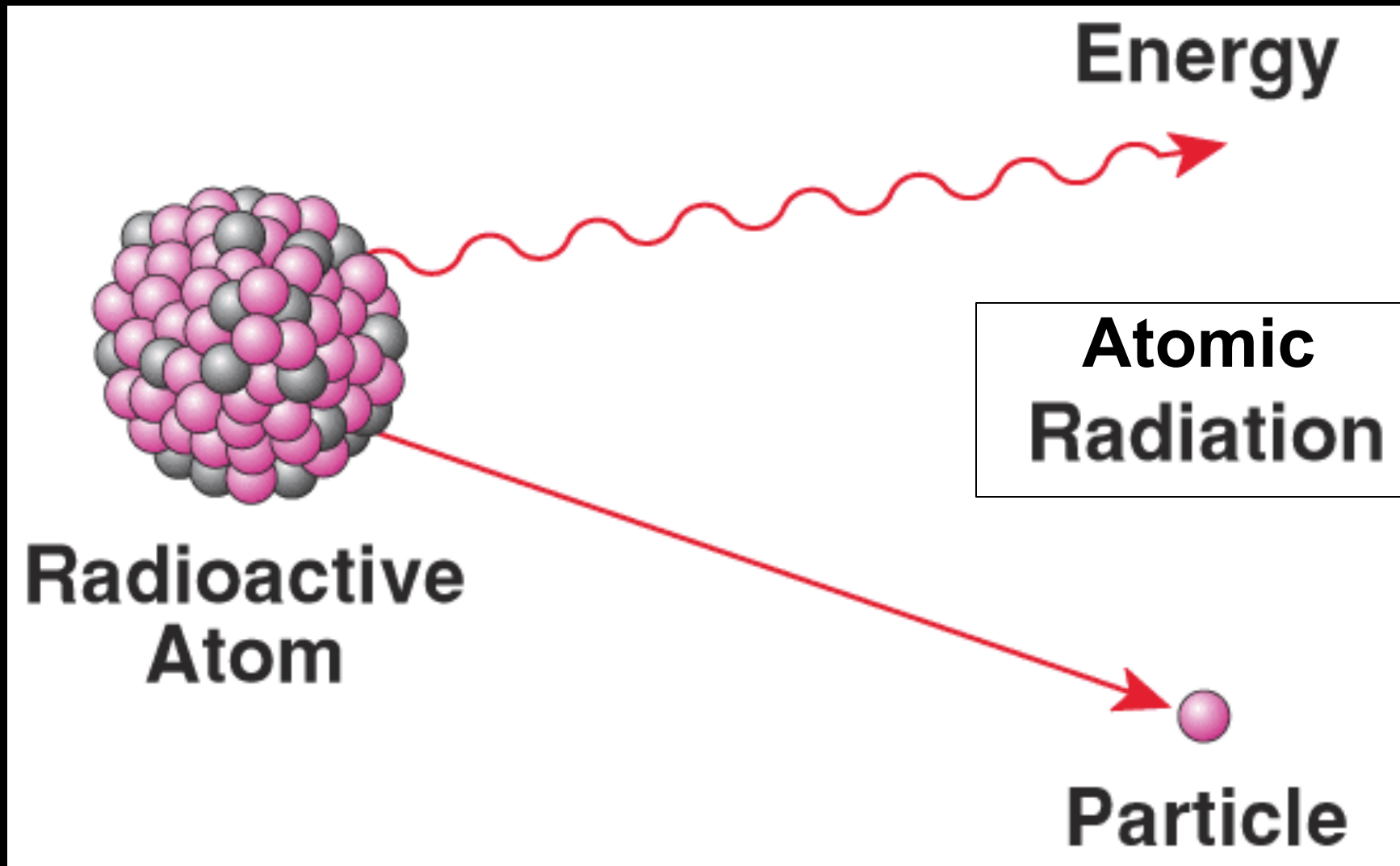
1. *Earthquake.*
2. *Reactor shutdown (immediate).*
3. *Tsunami – backup generators flooded; blackout !*
4. *Temperature rises due to radioactive decay heat.*
5. *Steam pressure rises – hydrogen gas is generated.*
6. *Steam vented; hydrogen explodes; roof blown off.*
7. *Escape of radioactive gases and vapors.*

Meanwhile the Reactor Cores are Melting Down.

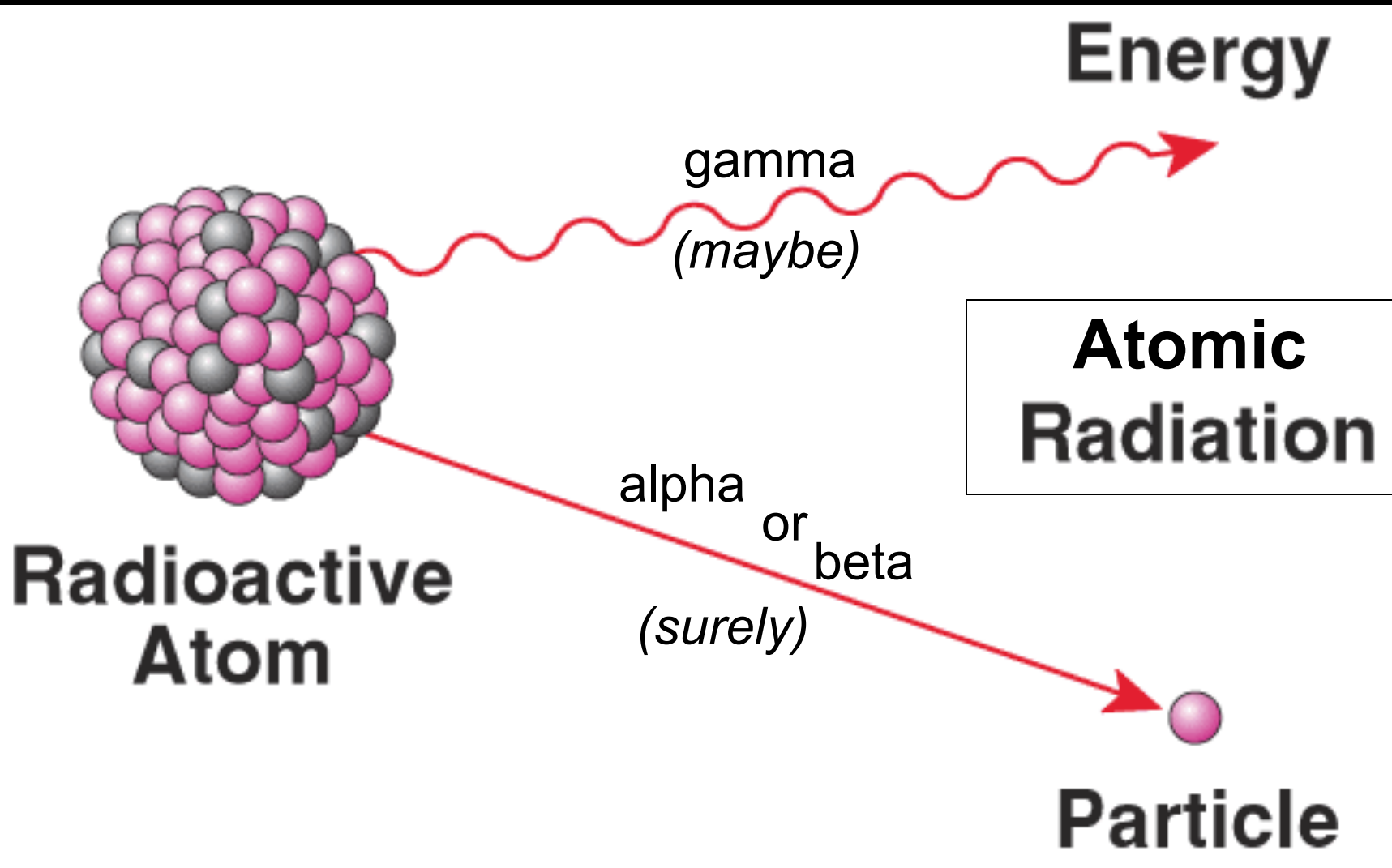
What is Radioactivity?

- Fission products are **radioactive**.
- Radioactive atoms are unstable – they **explode**.
- An exploding atom throws off damaging subatomic shrapnel – an **alpha** or **beta particle** – and sometimes a **gamma ray**.
- A **becquerel** indicates one explosion per second.

When a radioactive atom “disintegrates” a projectile is given off, and sometimes also a burst of energy in the form of electromagnetic radiation.



Every radioactive material is either a “beta-emitter” or an “alpha-emitter”.
Some radioactive materials (but not all !) are also “gamma-emitters”.



Four Types of Atomic Radiation

Internal hazards (non-penetrating radiation)

Alpha

Beta

External hazards (penetrating radiation)

Gamma

Neutron

Four Types of Atomic Radiation

Internal hazards (non-penetrating radiation)

Alpha

MAIN LONG-TERM HAZARD FOR CIVILIANS

Beta

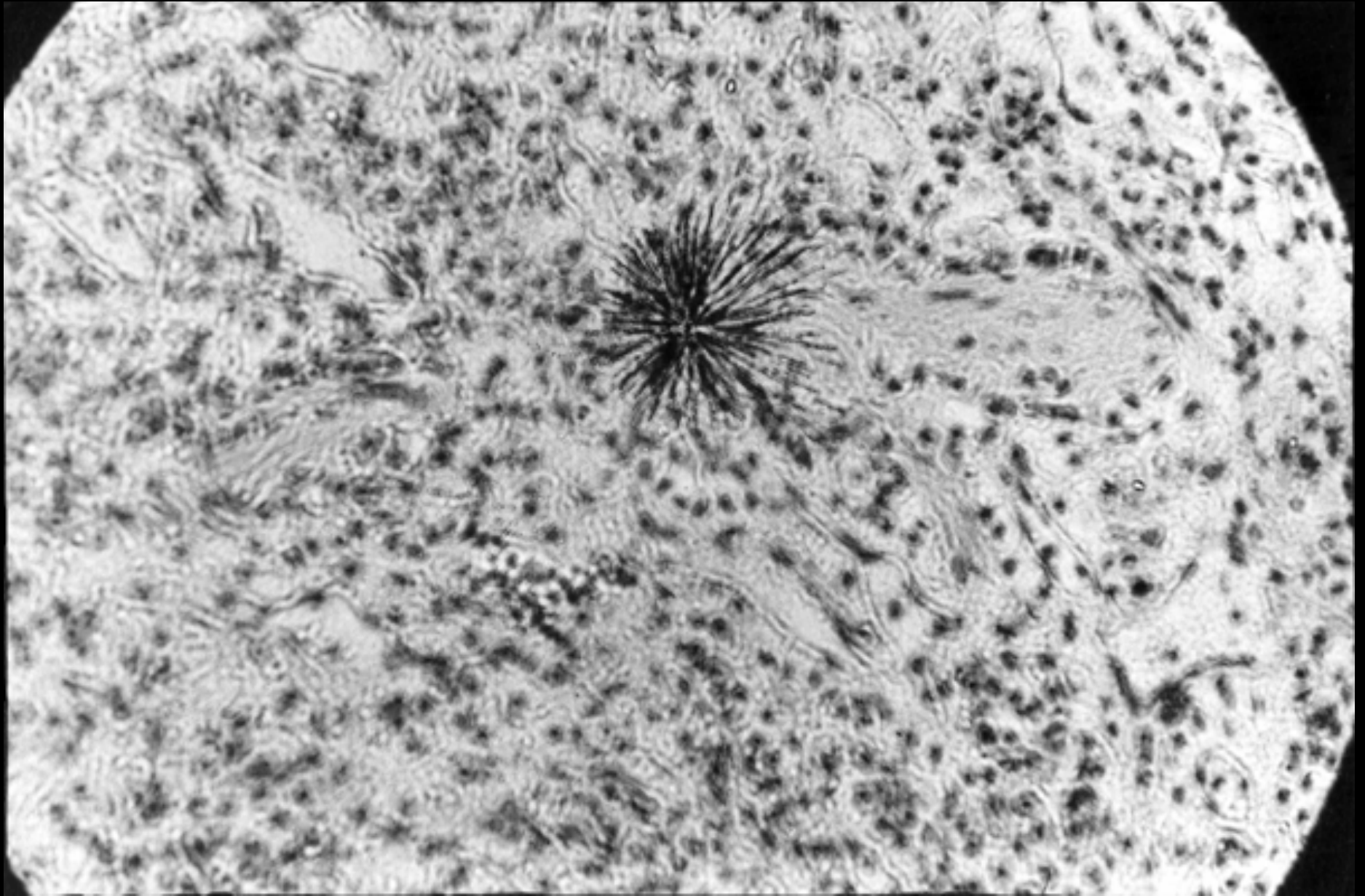
External hazards (penetrating radiation)

Gamma

MAIN SHORT-TERM HAZARD FOR WORKERS

Neutron

An alpha-emitting particle in the lung tissue of an ape



IONIZING RADIATION

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

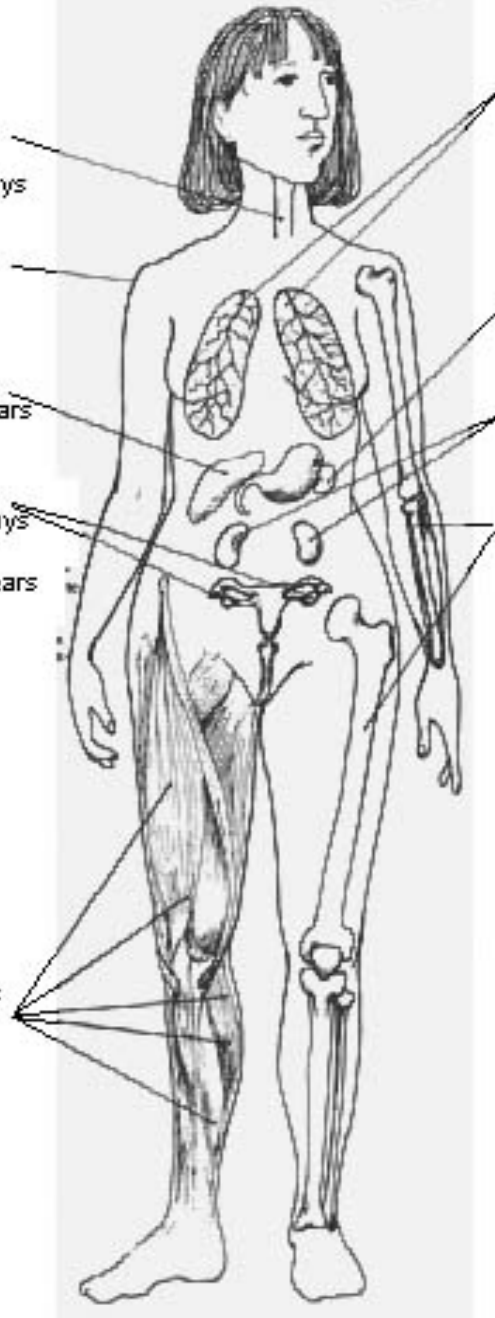
cesium-137
gamma ; 30 years

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

Fission Products
are chemical
substances
that are also
radioactive.

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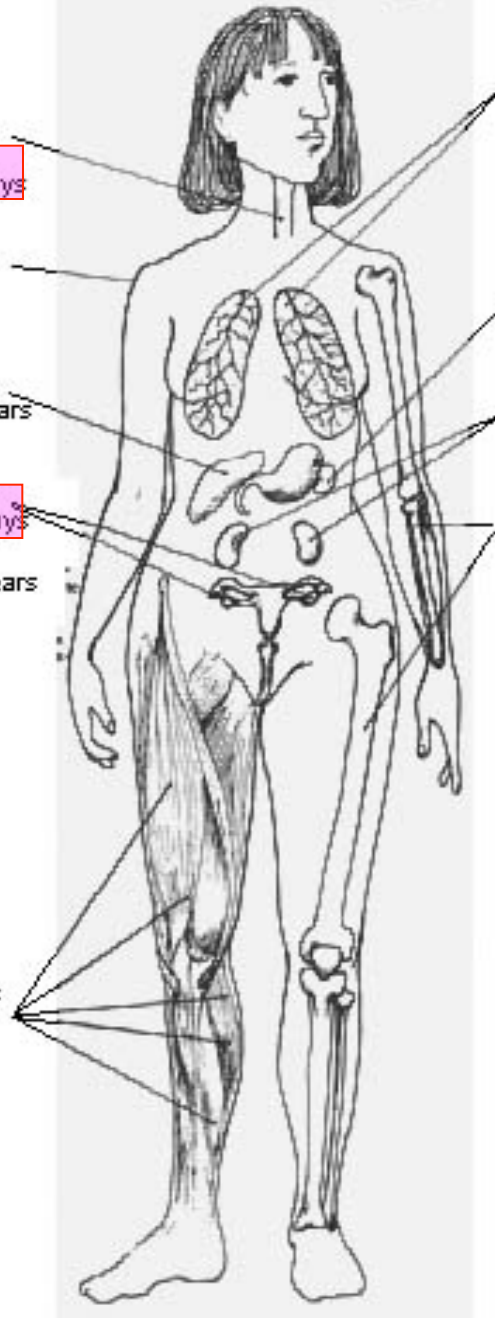
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carbon-14 (and fat)
beta ; 5 600 years

Iodine-131 goes to the thyroid gland (in the neck) and damages it.

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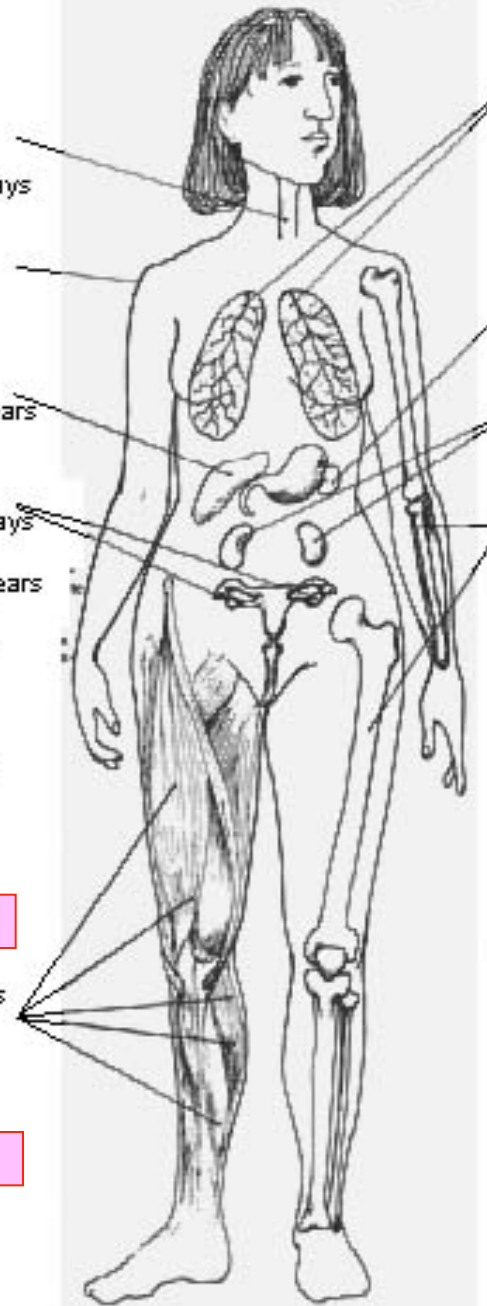
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Cesium-137
goes to the
soft tissues

(makes meat
unfit as food.)

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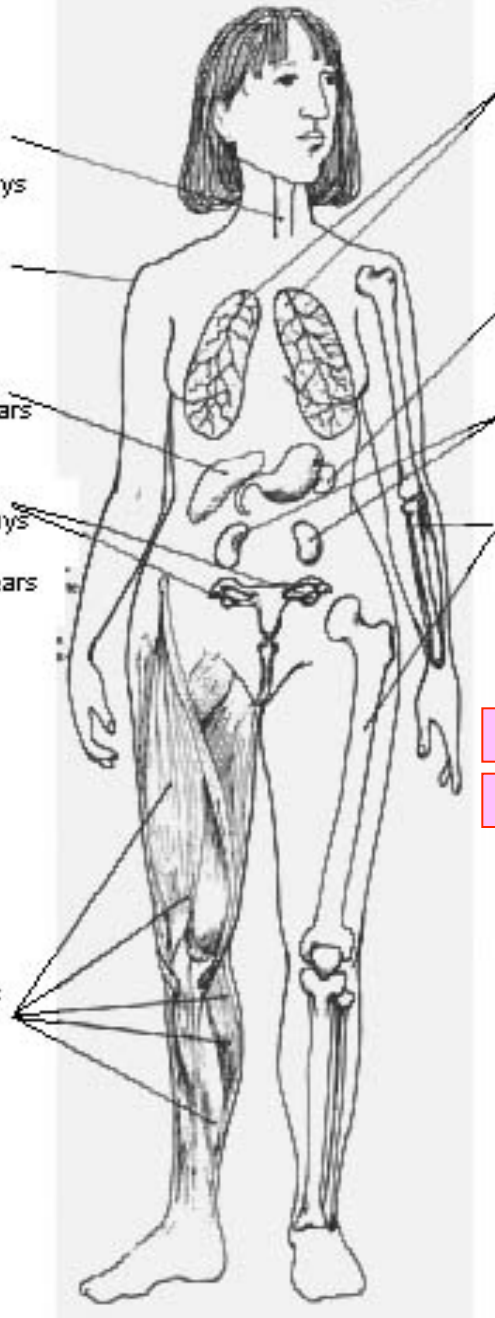
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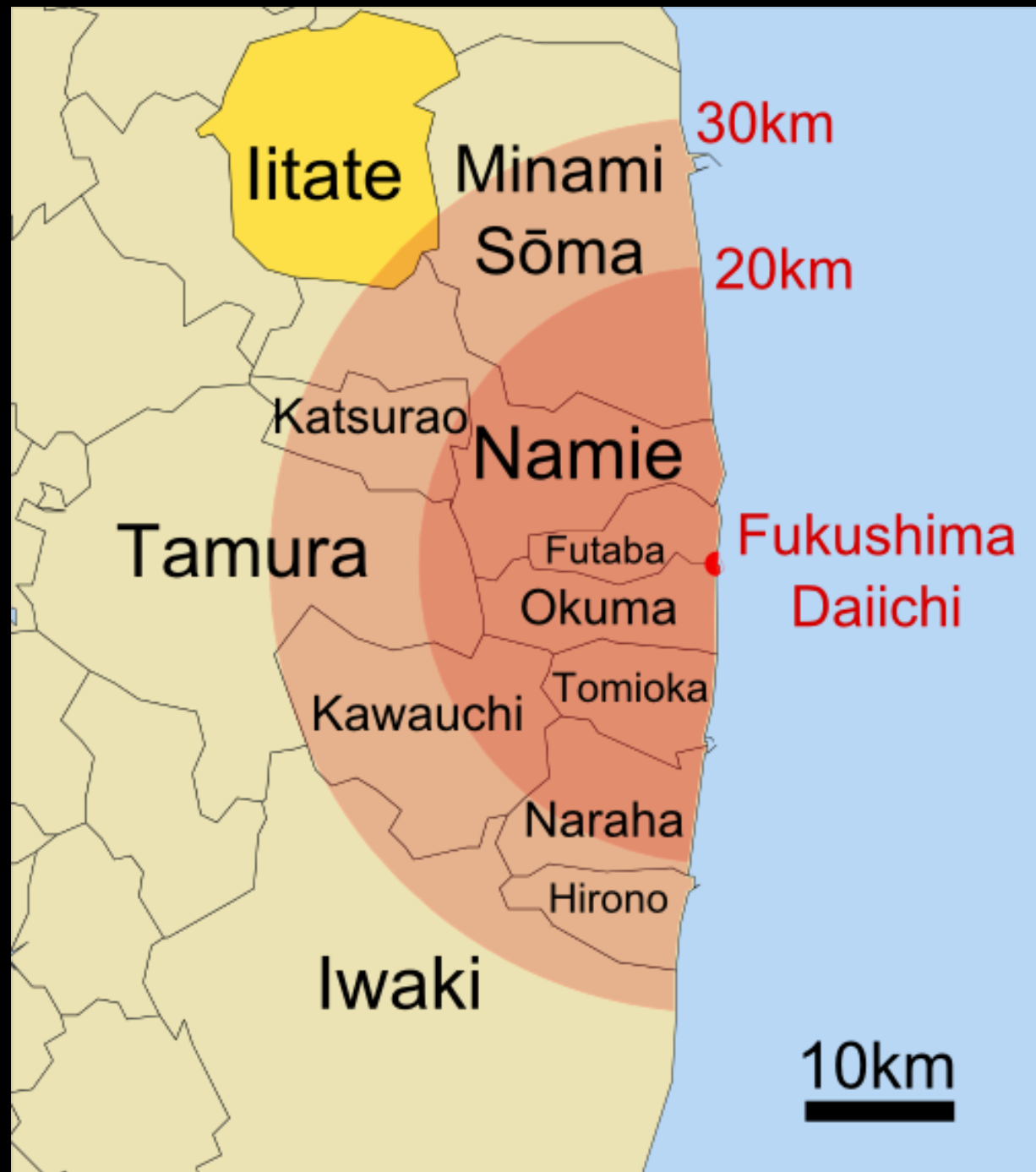
beta ; 5 600 years

Strontium-90
behaves like
calcium; it goes
to the bones,
the teeth and
mother's milk.

Citizens within 20 kilometres of Fukushima Daiichi were evacuated.

Citizens within 30 kilometres of Fukushima Daiichi were ordered to be “evacuation ready”.

But the Town of Iitate, more than 30 km away, also had to be evacuated.



radioactive cesium

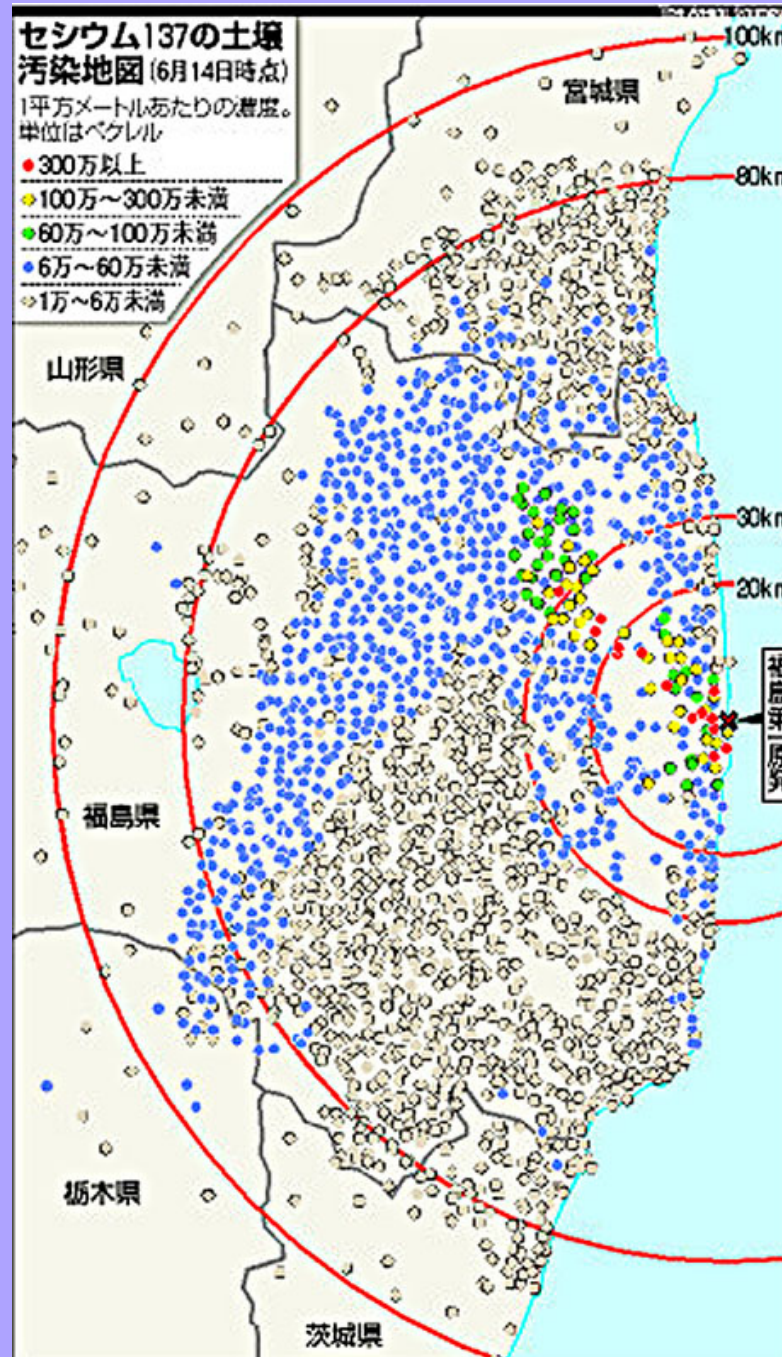
(August 2011)

red = over 3 million Bq/m²
yellow = 1 to 3 million Bq/m²
green = 600,000 to 1 million
blue = 60,000 to 600,000
grey = 10,000 to 60,000

maximum = 30 million Bq/m²

August 29, 2011

Chernobyl evacuation
criterion:
555,000 becquerels/m²



Extensive cesium contamination within 100 km of the crippled reactors

The yellow dots are hard to see, but they indicate a high degree of Contamination

The blue dots are borderline for evacuation

20 millisieverts per year is the maximum allowed for atomic workers in the EU

Some irregular areas were added to the original 20 km semicircular evacuation zone – radiation exposures in this area exceed those allowed for EU atomic workers

Special Decontamination Area

Target Goal:
GET Additional radiation exposure levels to below 20mSv/yr

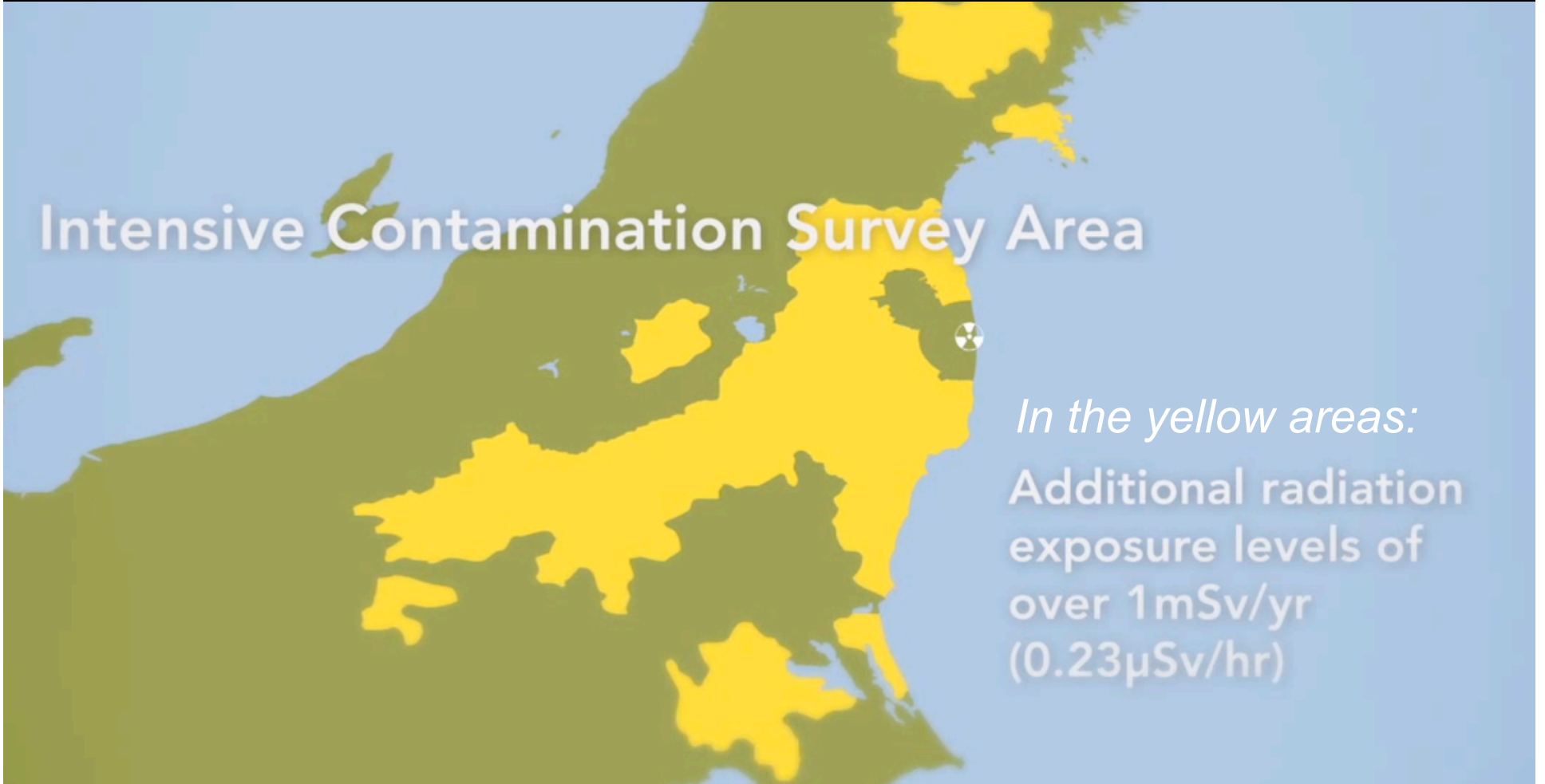


1 millisievert per year is the maximum allowable for a member of the public in Canada

The irregular evacuation zone is here shown in green; in the yellow areas shown below, evacuation did not take place, but decontamination efforts are underway.

Intensive Contamination Survey Area

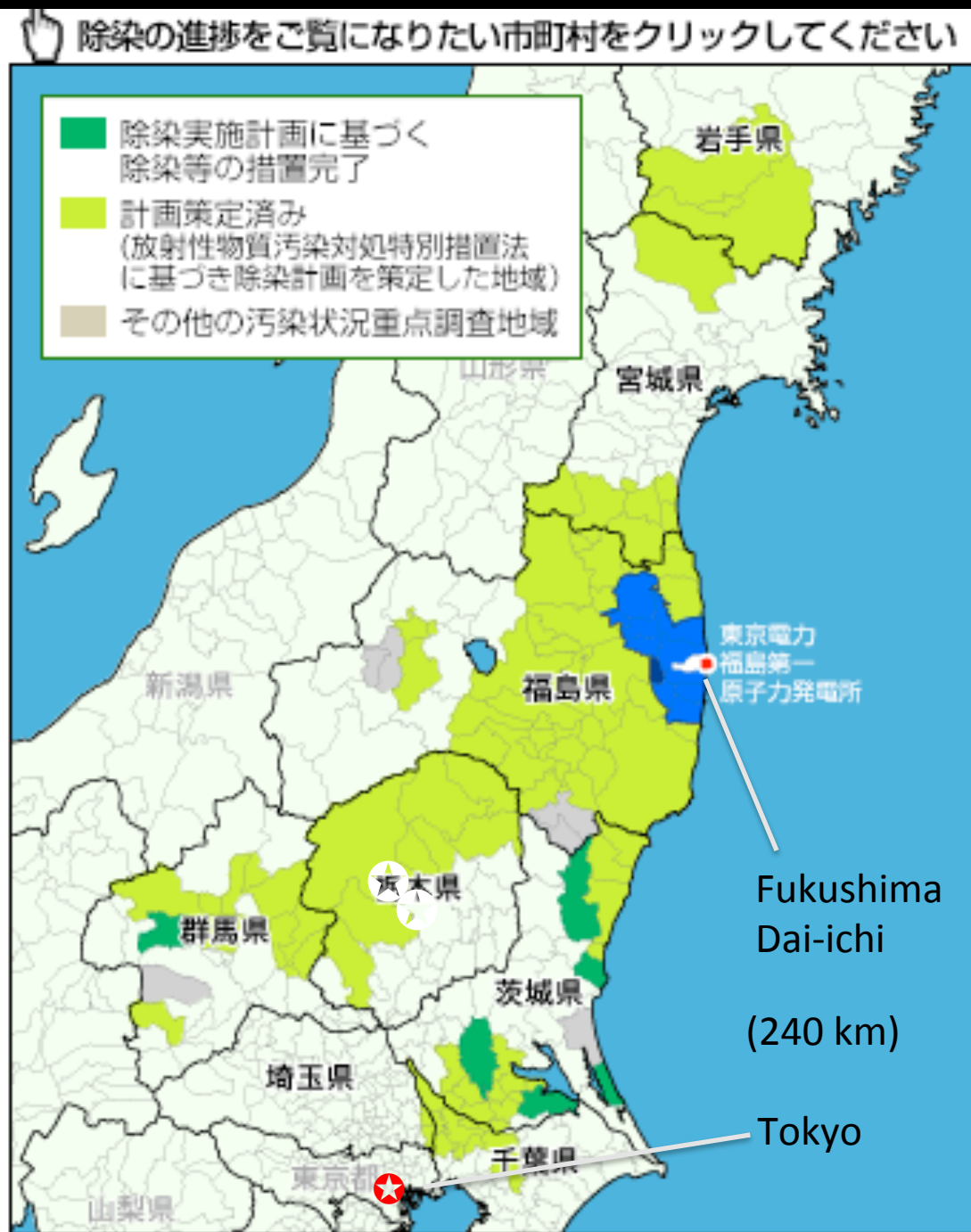
*In the yellow areas:
Additional radiation
exposure levels of
over 1mSv/yr
(0.23 μ Sv/hr)*



These green areas correspond to the yellow areas shown in the previous map.

The irregular evacuation area appears in blue.

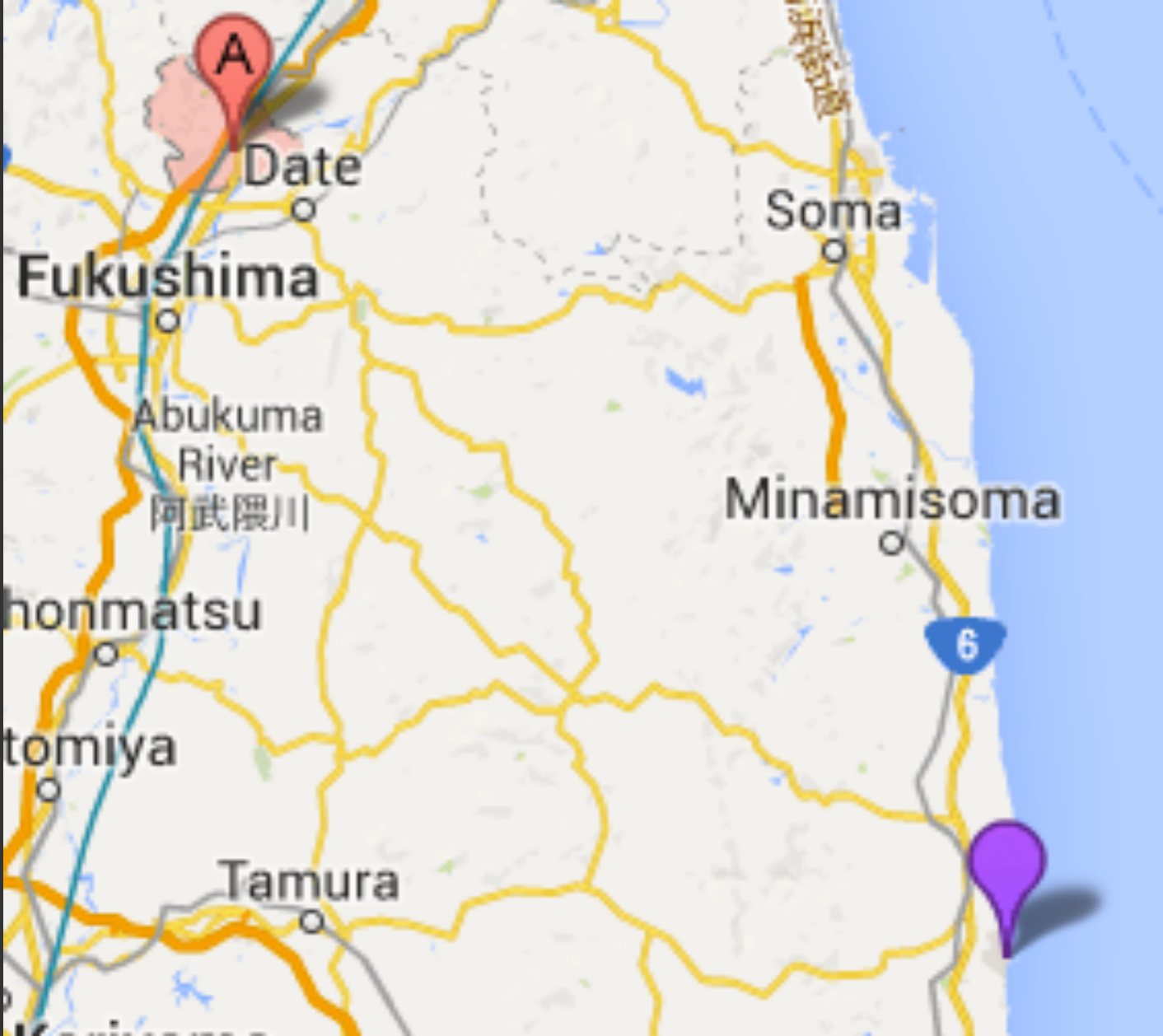
Although Tokyo is shown as unaffected, Arnie Gundersen found that soil samples from Tokyo would be classed as radioactive waste in the USA.




RED MARKER = TOWN OF KOORI

65 km

PURPLE MARKER = Fukushima Daiichi





This gentleman is from the
Town of Koori, 65 kilometres
Northwest of Fukushima Daiichi

This, and the following images,
are from an August 2013 video
put out by Japan's Ministry of
the Environment.

The caption below is part of the
government video.

**I have been furious at TEPCO
and the Japanese government.**


Despite his anger, he wants to help gov't officials with decontamination efforts.



**we keep close communication
to gain full consent on our work.**

Radioactive soil must be removed; forest floor is stripped only within 200m of homes.





**once you step outside
the levels are still high.**

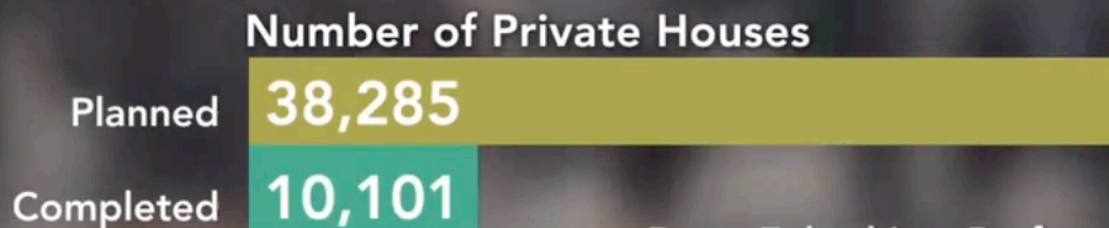
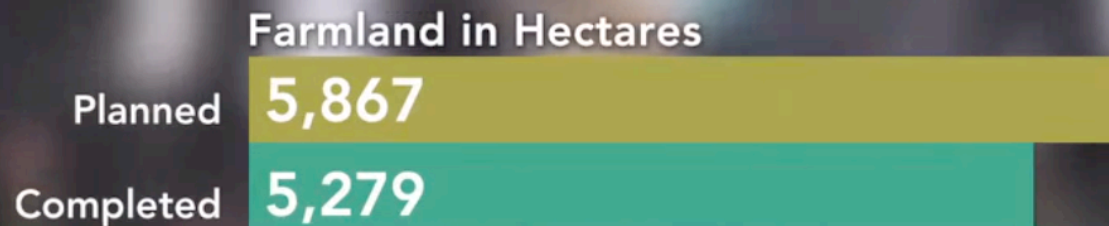
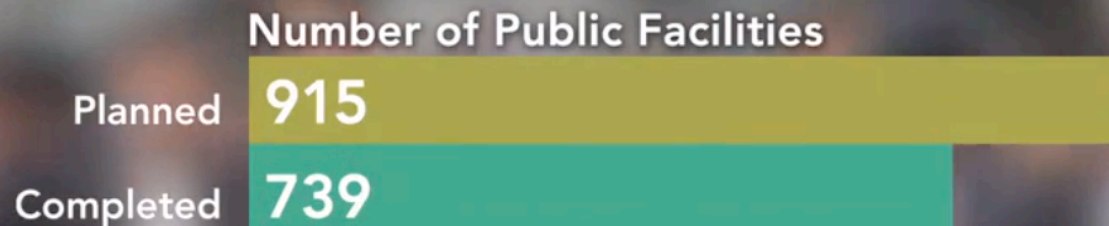
Garden soil is also removed. Radioactive moss is even scrubbed from garden rocks.



so they will scrape the moss off.

Decontamination of a home takes several days or weeks. Two years after the disaster, only about 1/4 of homes in Fukushima City have been decontaminated.

Decontamination Progress of Fukushima City as of June 2013



Data: Fukushima Prefectural Government

Sacks of contaminated materials are stored in the town, against the wishes of many residents – but better this than nothing. Here we see 4 levels of sacks.



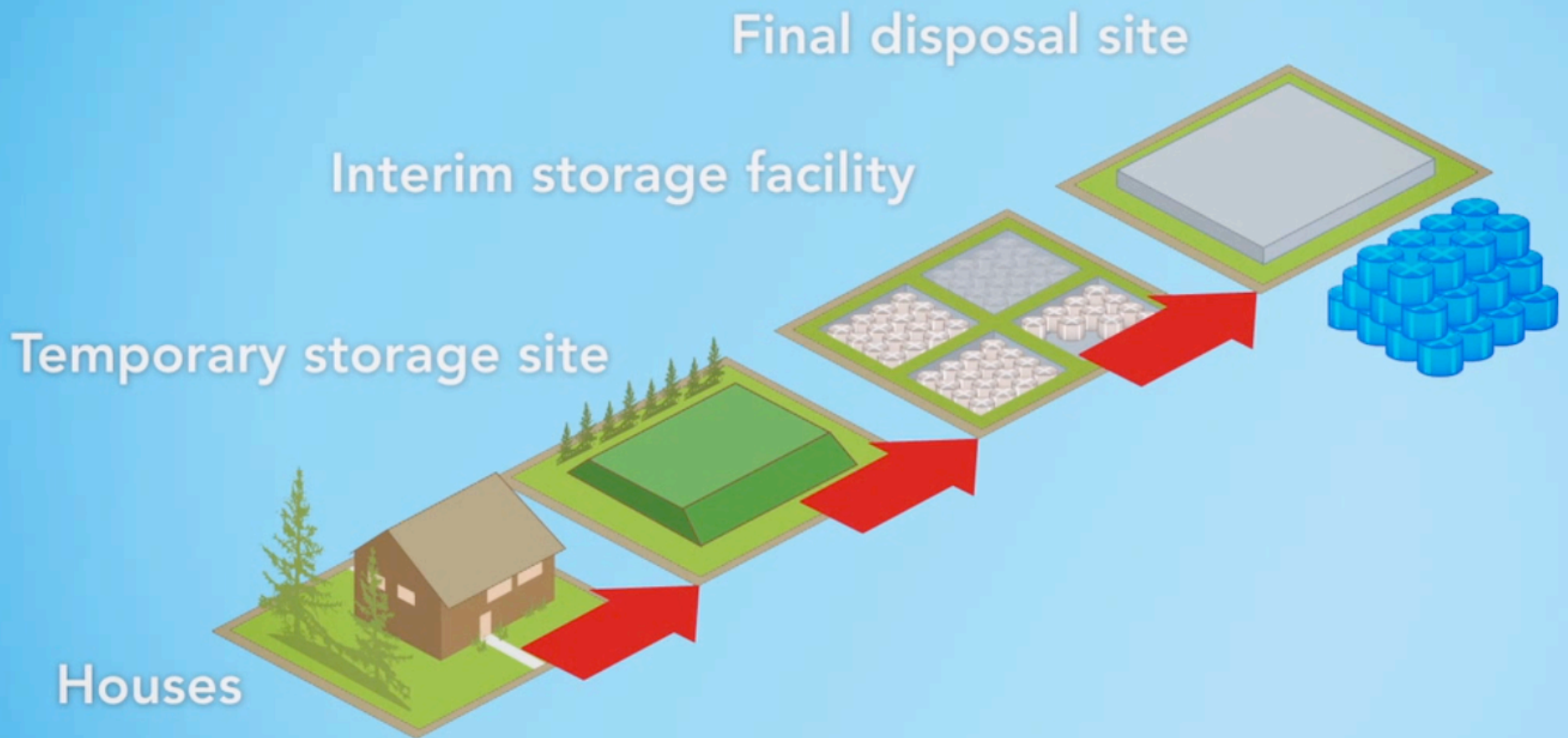
Another local storage area for sacks of contaminated material that will remain dangerous for several centuries (cesium-137 has 30 yr half-life).



Behind this retaining wall are many more sacks of radioactive waste.
(Let's hope they don't get washed away by a typhoon.)



Eventually all these sacks in all these towns will get to an interim facility, but That's still a long way away it seems. Japan has no final disposal site either.



Meanwhile, contaminated water is accumulating – and leaking -- at Fukushima Daiichi



FUKUSHIMA LEAK WORSE THAN THOUGHT
JAPAN NUCLEAR PLANT BATTLES TO CONTAIN RADIOACTIVE WATER

CTV
NEWS
CHANNEL

400 tons of water per day are pumped through the 3 molten cores to prevent them from over-heating; the water ends up so contaminated it must be stored in tanks.



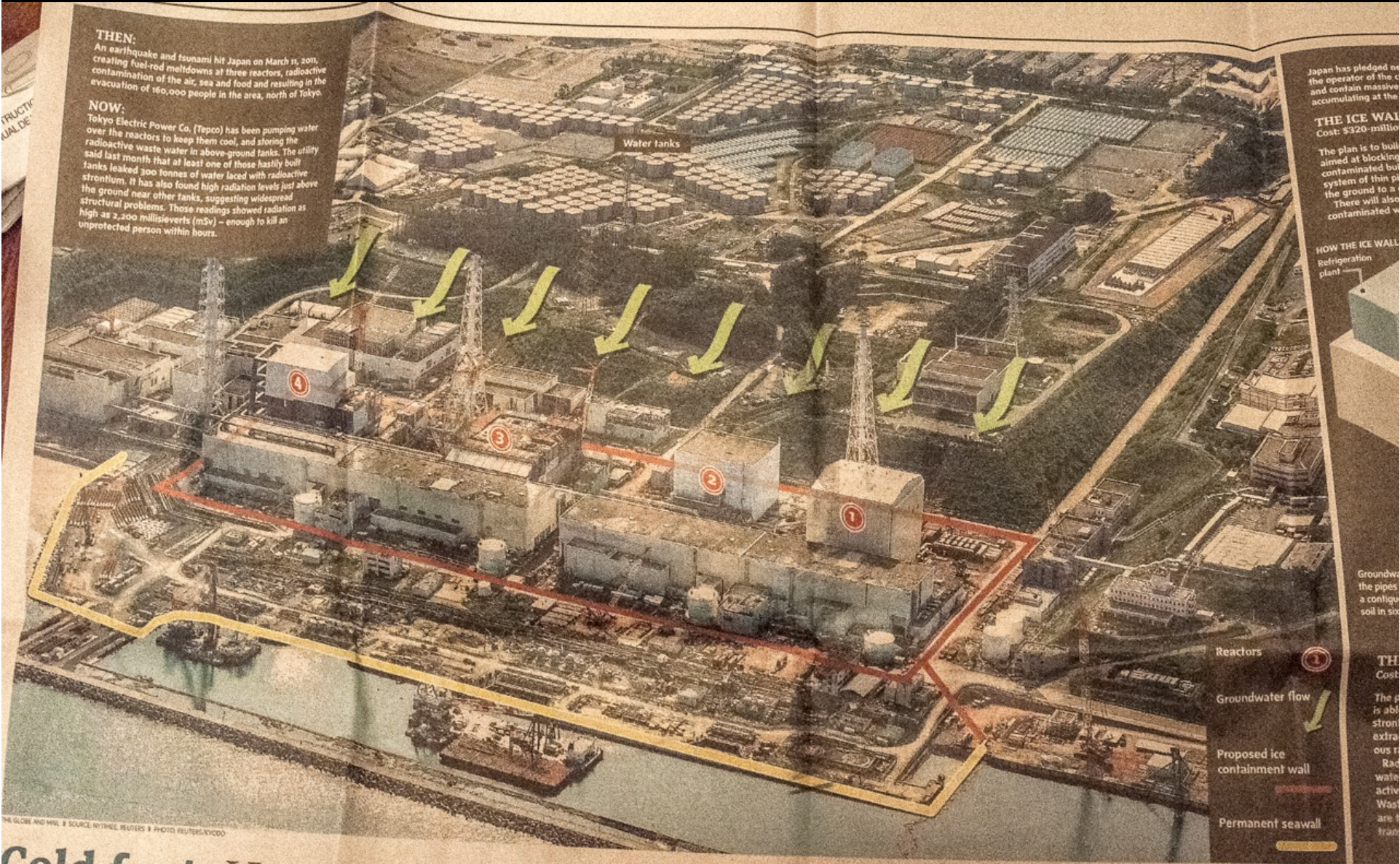
More than 1000 tanks are already filled with more being added all the time.

A forest has been cut down to make room for more tanks.

Equipment removes 62 different varieties of radionuclides but some (like tritium) cannot be removed at all.



Meanwhile contaminated groundwater enters the Pacific at 300 tonnes per day.



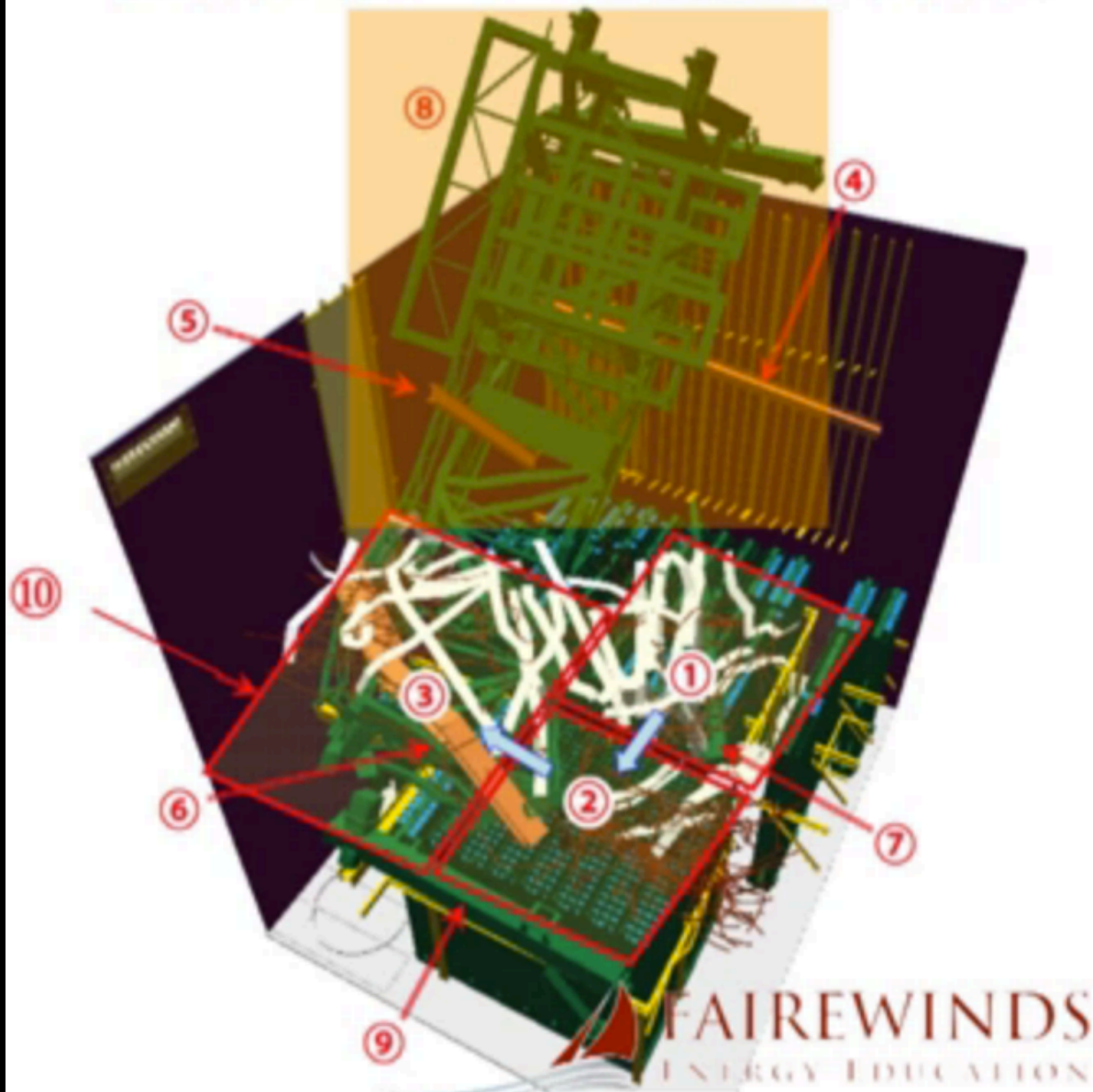
Cold feat: How Japan plans to contain Fukushima's nuclear contamination

... as workers prepare to remove 1500 irradiated fuel assemblies from Unit 4



A TEPCO Report of January 31 2014 reveals great damage – 50 tons of equipment has fallen into the pool, damaging irradiated fuel assemblies

<使用済燃料プール内瓦礫撤去作業状況>



Removing all
Irradiated fuel from
the pools in units 1-4

as well as the molten
cores of units 1-3

will take at least
40 years

and may precipitate
further radioactive
releases

Criminal gangs are recruiting destitute men to work at Fukushima Daiichi

. . . and taking most of their pay



Is this sad Soviet experience a harbinger of things to come in Japan?



These young women from the small town of Muslimuovo just learned of the radioactive contamination of the Techa River that flows past their town.