The Abdus Salam
International Centre
for Theoretical Physics

2473-44

Joint ICTP-IAEA School on Nuclear Energy Management

15 July - 3 August, 2013

Lecture Notes/2

A.J. Gonzalez
Autoridad Regulatoria Nuclear
Buenos Aires
Argentina

Strada Costiera, 11 - 34151 - Trieste - Italy • Tel. +39 0402240111 • Fax. +39 040224163 • sci_info@ictp.it • www.ictp.it
ICTP is governed by UNESCO, IAEA, and Italy, and it is a UNESCO Category 1 Institute

International Centre for Theoretical Physics-International Atomic Energy Agency

The ICTP/IAEA Nuclear Energy Management School 2013

International Centre for Theoretical Physics, Miramare, Trieste, Italy; July 30, 2013

Overview and Lessons Learned from the Major Global Nuclear Accidents

Abel J. González

Vice-Chair of the International Commission on Radiological Protection (ICRP)

Member of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)

Member of the Commission of Safety Standards of the IAEA

Autoridad Regulatoria Nuclear; ✉Av. Del Libertador 8250; (1429)Buenos Aires, Argentina; ☎+54 1163231758; 🖷 agonzalez@arn.gob.ar

Content

1. Radiation accidents
2. Nuclear accidents
3. Epilogue

Part 1:

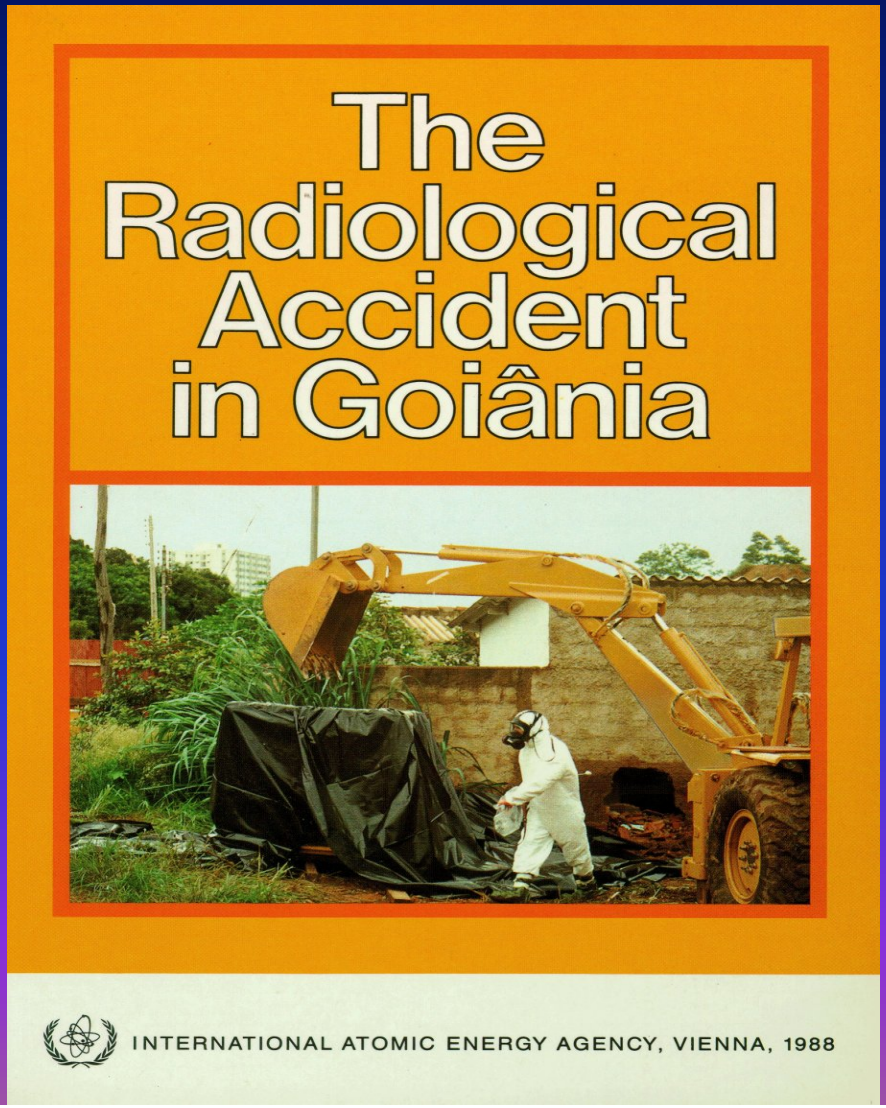
Radiation Accidents

The First Recorded International Experience

The Radiological Accident in Goiânia

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 1988

Revisiting Goiânia



Revisiting Goiânia

- ✓ Unsecured caesium 137 source in radiological clinic.
- ✓ Scrap scavengers break in, steal and move it to junkyard.
- ✓ Source capsule rupture: dispersible and soluble CsCl.
- ✓ City contaminated.
- ✓ 14 people overexposed; 4 died within 4 weeks.
- ✓ 112 000 people monitored; 249 contaminated.
- ✓ 85 houses contaminated; hundreds of people evacuated.
- ✓ >5000 m^3 of radioactive wastes.

Preparing to demolish the contaminated houses

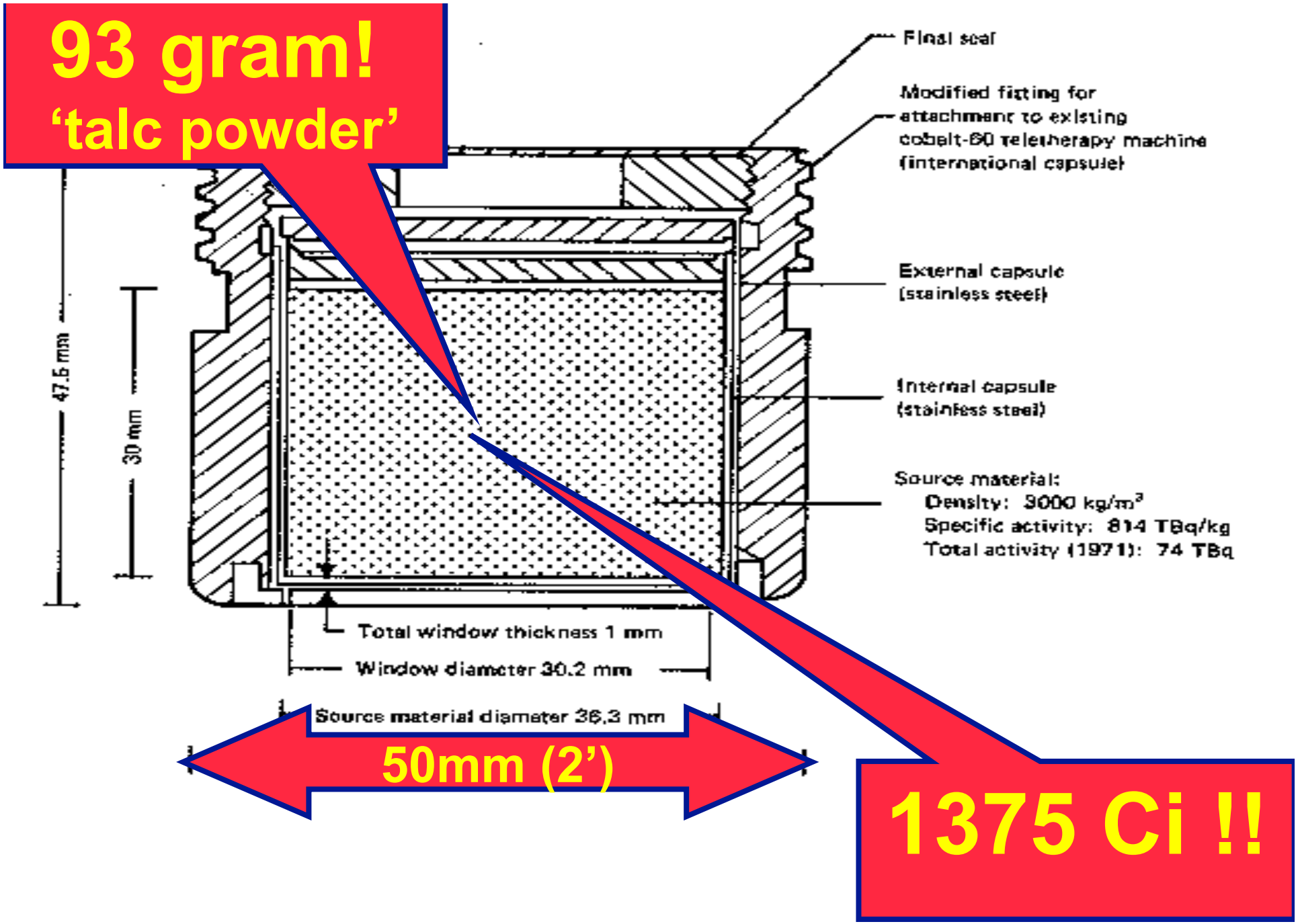
Demolishing work: dose rates up to 0.5 Sv/h

Contaminated rubble from a house

Restoration after removing the contaminated rubble

Stacking radioactive waste containers

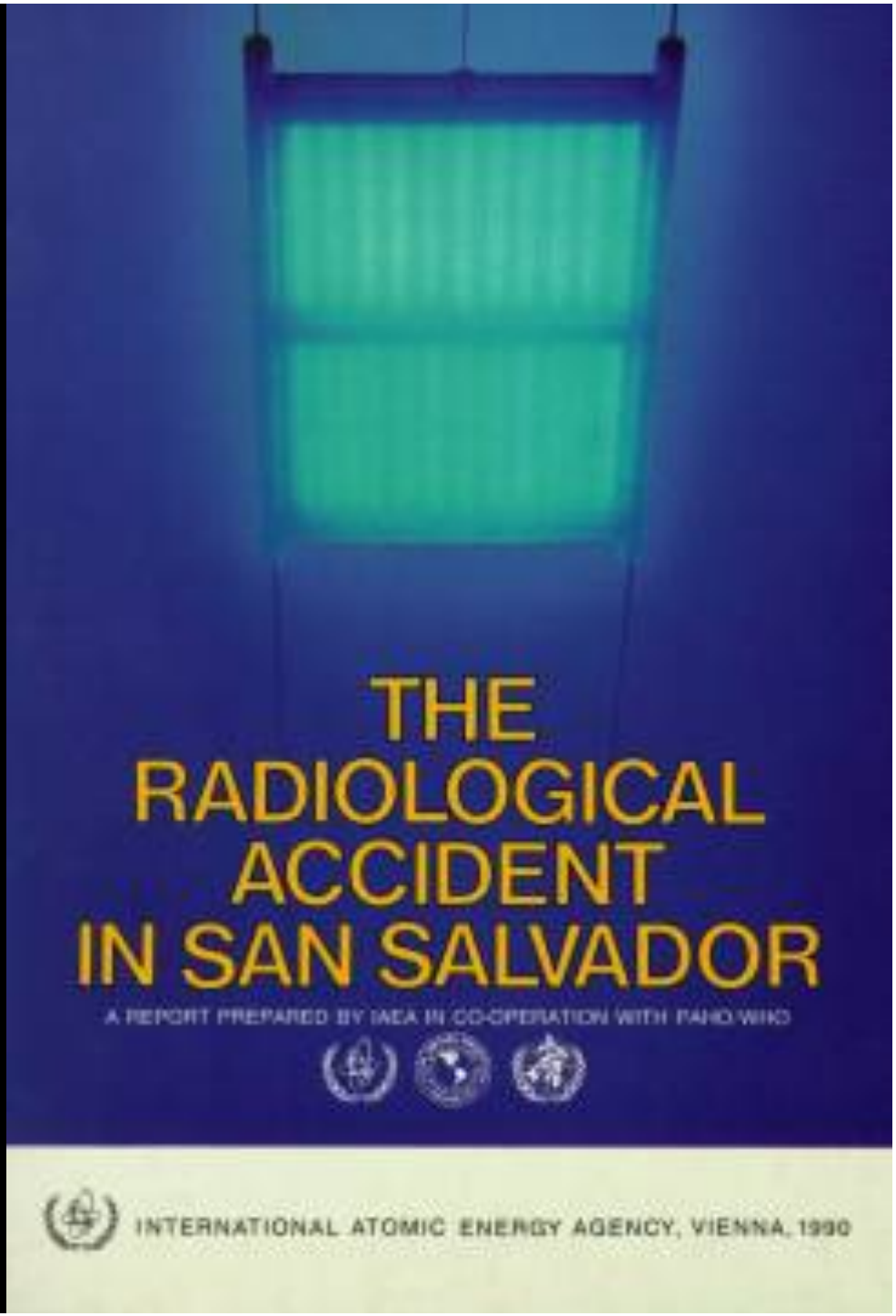
Temporary radioactive waste repository


93 gram!
'talc powder'
Final seal
Modified fitting for attachment to existing cobalt-60 teletherapy machine (international capsule)
External capsule (stainless steel)
Internal capsule (stainless steel)
Source material:
Density: 3000 kg/m³
Specific activity: 814 TBq/kg
Total activity (1971): 74 TBq
47.5 mm
30 mm
Total window thickness 1 mm
Window diameter 30.2 mm
Source material diameter 36.3 mm
50mm (2')
1375 Ci !!

Following Goiânia, an international system for reviewing events become operative

Some industrial radiation accidents

- 5 February 1989
- industrial irradiation facility
- San Salvador, El Salvador
- cobalt-60 source in a movable source rack
- source rack became stuck in the irradiation position
- operator bypassed the irradiator's already degraded safety systems
- entered the radiation room with two other workers to free the source rack manually



- 21 June 1990
- Soreq, Israel,
- radioactive cobalt-60 source in a movable source rack.
- source rack became stuck in the irradiation position owing to obstruction by cartons on the internal conveyor.
- The operator,
  - misinterpreted two conflicting warning signals,
  - bypassed installed safety systems and
  - contravened procedures
  - enter the irradiation room to free the blockage.

The Radiological Accident in Soreq

IAEA

- 26 October 1991,
- irradiation facility in Nesvizh, Belarus.
- agricultural and medical products being sterilized
- ^{60}Co source in a moveable rack.
- jam in the product transport system
- the operator
  - entered the facility to clear the fault,
  - bypassing a number of safety features.

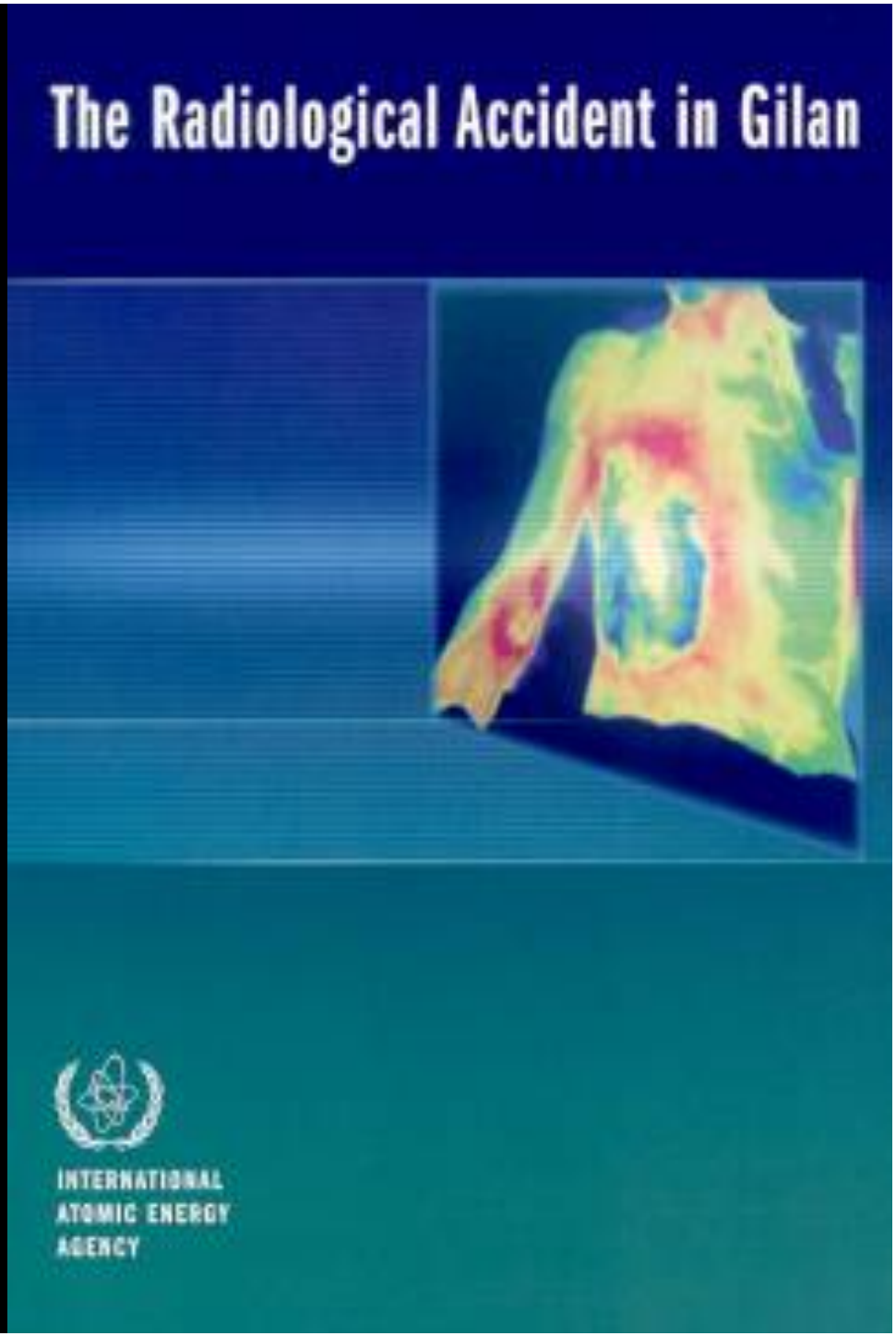
THE RADIOLOGICAL ACCIDENT AT THE IRRADIATION FACILITY IN NESVIZH

IAEA

- In 1993, in Ankara, Turkey
- Importer loaded three spent radiotherapy sources in preparation for returning them to USA.
- The packages were not send but stored in Ankara from 1993 until 1998,
- In February 1998 the two packages transported to Istanbul, stored, and then moved, and after nine months, transferred
- Purchaser unaware of the radiation hazard.
- Broke open the shielded containers,
- This occurred in the residential area of Ikitelli in the Kuciikekmece district of Istanbul on 10 December 1998.
- On 13 December 1998, a total of ten persons fell ill and six of them began to vomit.
- The cause of the illness was not recognized until almost four weeks later (on 8 January 1999).

The Radiological Accident in Istanbul

- On 24 July 1996
- Gilan, Islamic Republic of Iran.
- A worker picked up a ^{192}Ir industrial radiography source and put it in his chest pocket, where it remained for approximately 1.5 h.



- 20 February 1999
- Yanango hydroelectric power plant in Peru.
- A welder picked up an ^{192}Ir industrial radiography source and put it in his pocket.
- Necessitated the amputation of one leg.
- His wife and children were also exposed.

The Radiological Accident in Yanango

- April 2002 Cochabamba, Bolivia
- ^{192}Ir source, in a remote exposure container, remained exposed within a guide tube
- The container and the guide tube were returned from Cochabamba to La Paz as cargo on a passenger bus, which carried a full load of passengers for the journey of about eight hours.

April 2nd, 2013

The Radiological Accident in Cochabamba

IAEA
International Atomic Energy Agency

The Radiological Accident in Nueva Aldea

- 14 December 2005
- cellulose plant under construction in Nueva Aldea, Concepción, Chile.
- After completing radiography, a radiographer dismantled the radiography equipment, not noticing that the source had fallen out on to the tower platform.

IAEA
International Atomic Energy Agency

Some medical

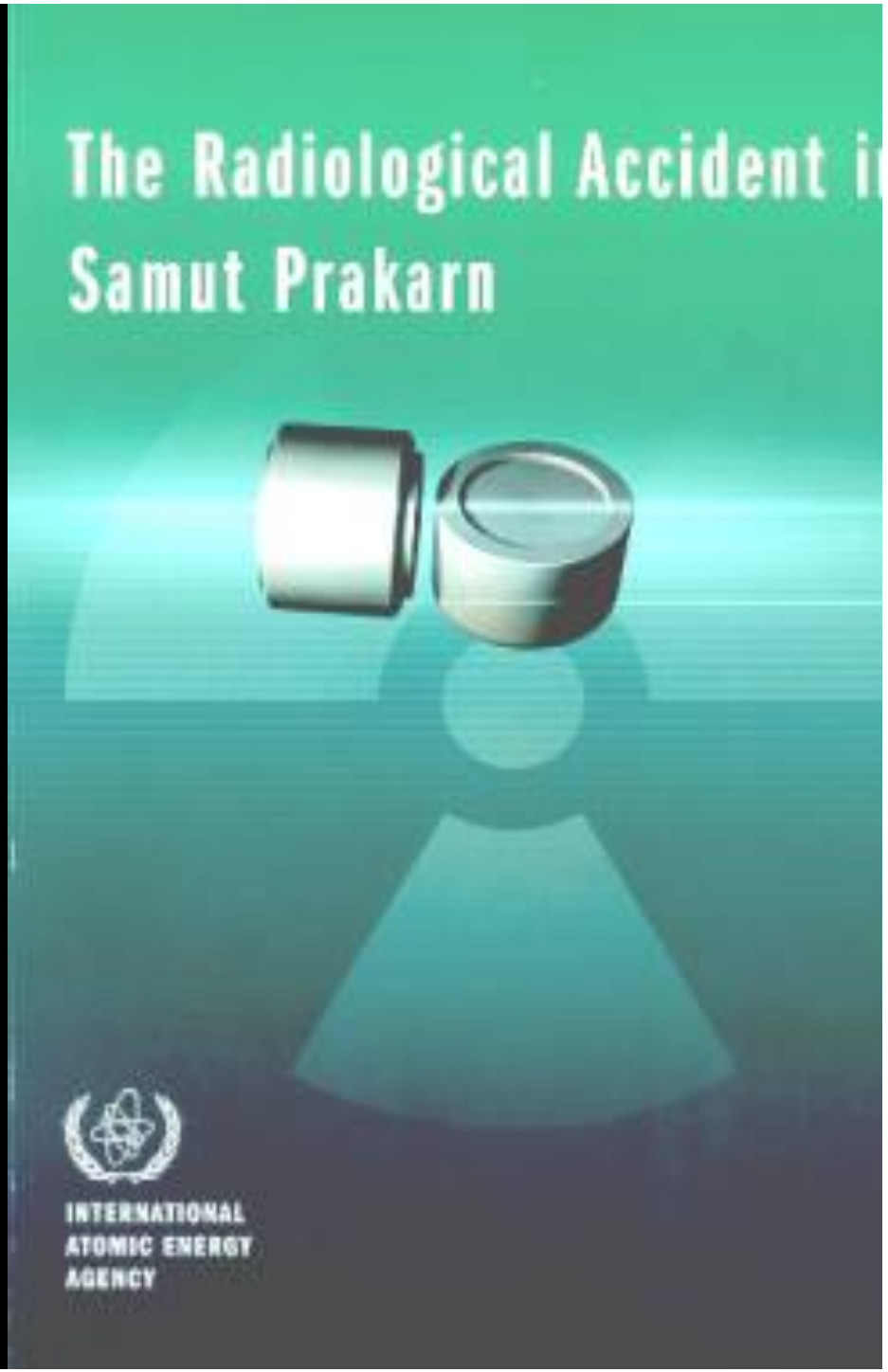
radiation accidents

- 22 August 1996
- San Juan de Dios Hospital in San José, Costa Rica
- ^{60}Co radiation therapy source was replaced and wrongly calibrated.
- The error resulted in the administration to patients of significantly higher radiation doses than those prescribed.
- This was a major radiation accident: 115 patients were affected.

Accidental Overexposure of Radiotherapy Patients in San José, Costa Rica

INTERNATIONAL ATOMIC ENERGY AGENCY

- In the 90's a company based in Bangkok, Thailand, possessed several teletherapy devices without authorization
- In late January 2000, a teletherapy head partially disassembled.
- On 1 February 2000, the device was moved to a junkyard in **Samut Prakarn, Thailand**.
- By the middle of February 2000, several individuals had begun to feel ill and sought medical assistance.



●27 February 2001,

● Oncology Centre in Białystok, Poland

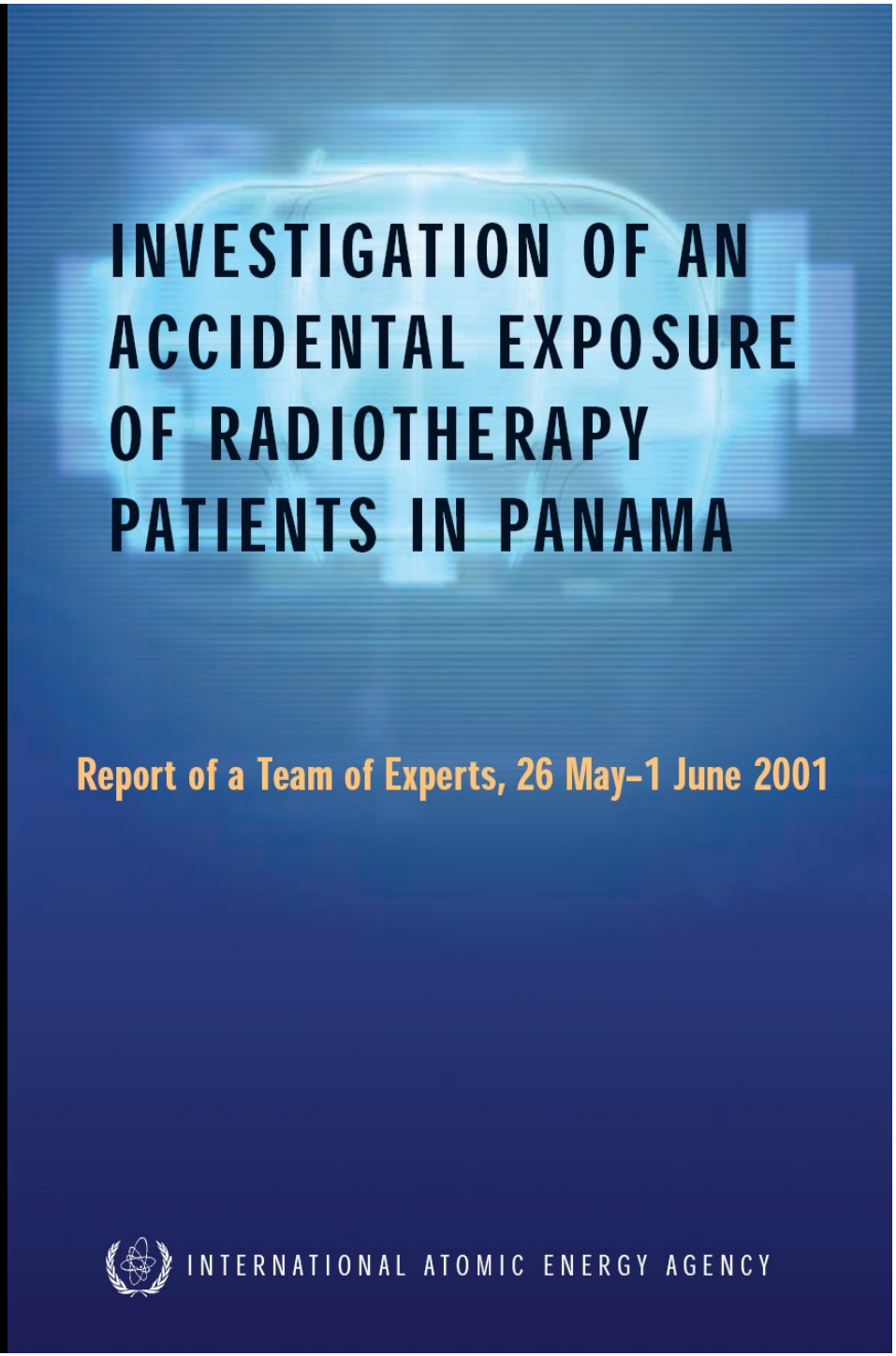
●patients undergoing radiotherapy were given significantly higher doses than intended and, as a result, developed radiation induced injuries.

April 2nd, 2013

Accidental Overexposure of Radiotherapy Patients in Białystok

IAEA
International Atomic Energy Agency

- A computerized treatment planning system (TPS) was used by the **Instituto Oncológico Nacional, in Panama,** to calculate doses and determine treatment times.
- In August 2000 the method of digitizing shielding blocks was changed.
- As a result, the computer output indicated a treatment time substantially longer.
- The modified treatment protocol delivered a proportionately **higher dose to 28 patients.**

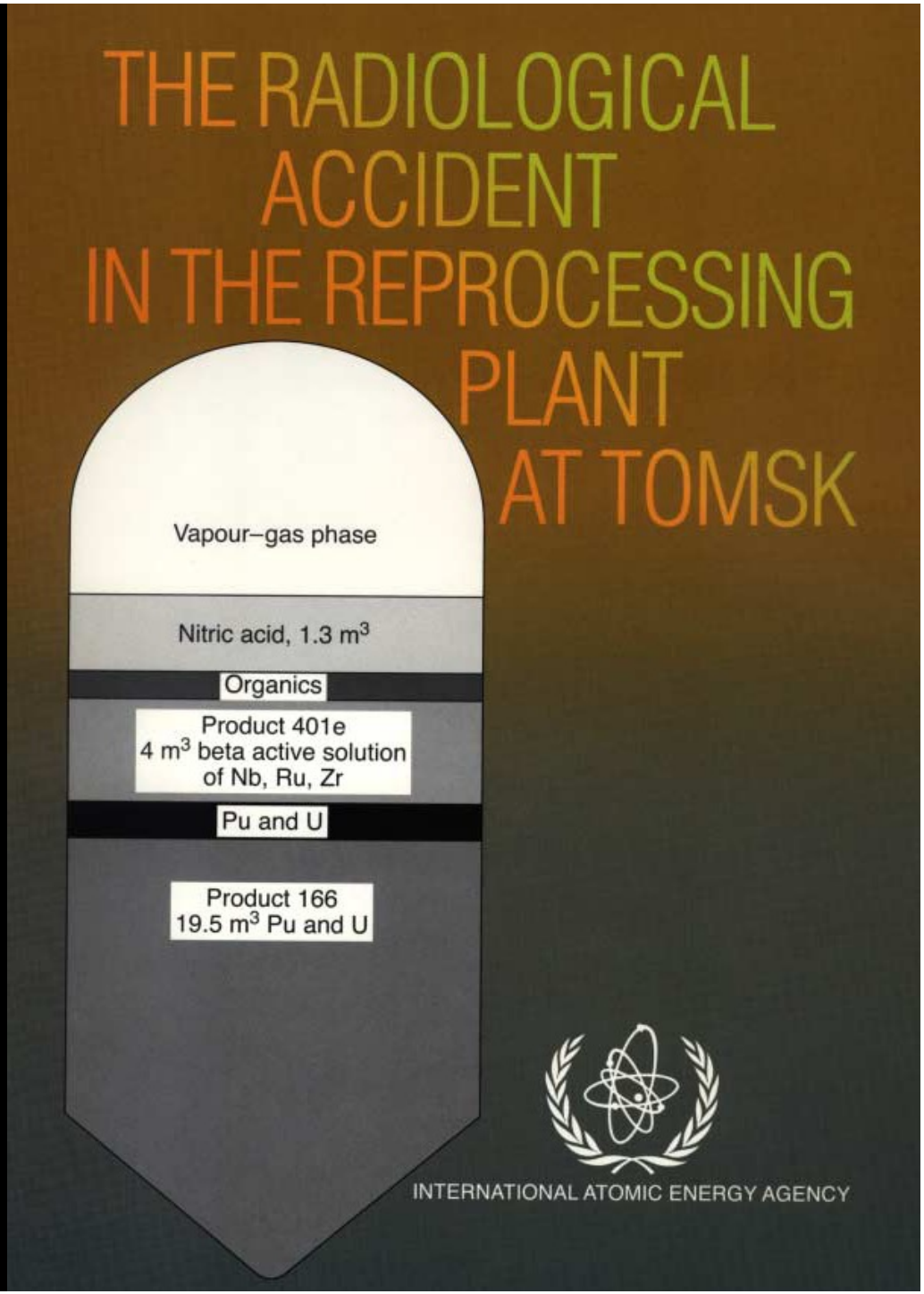


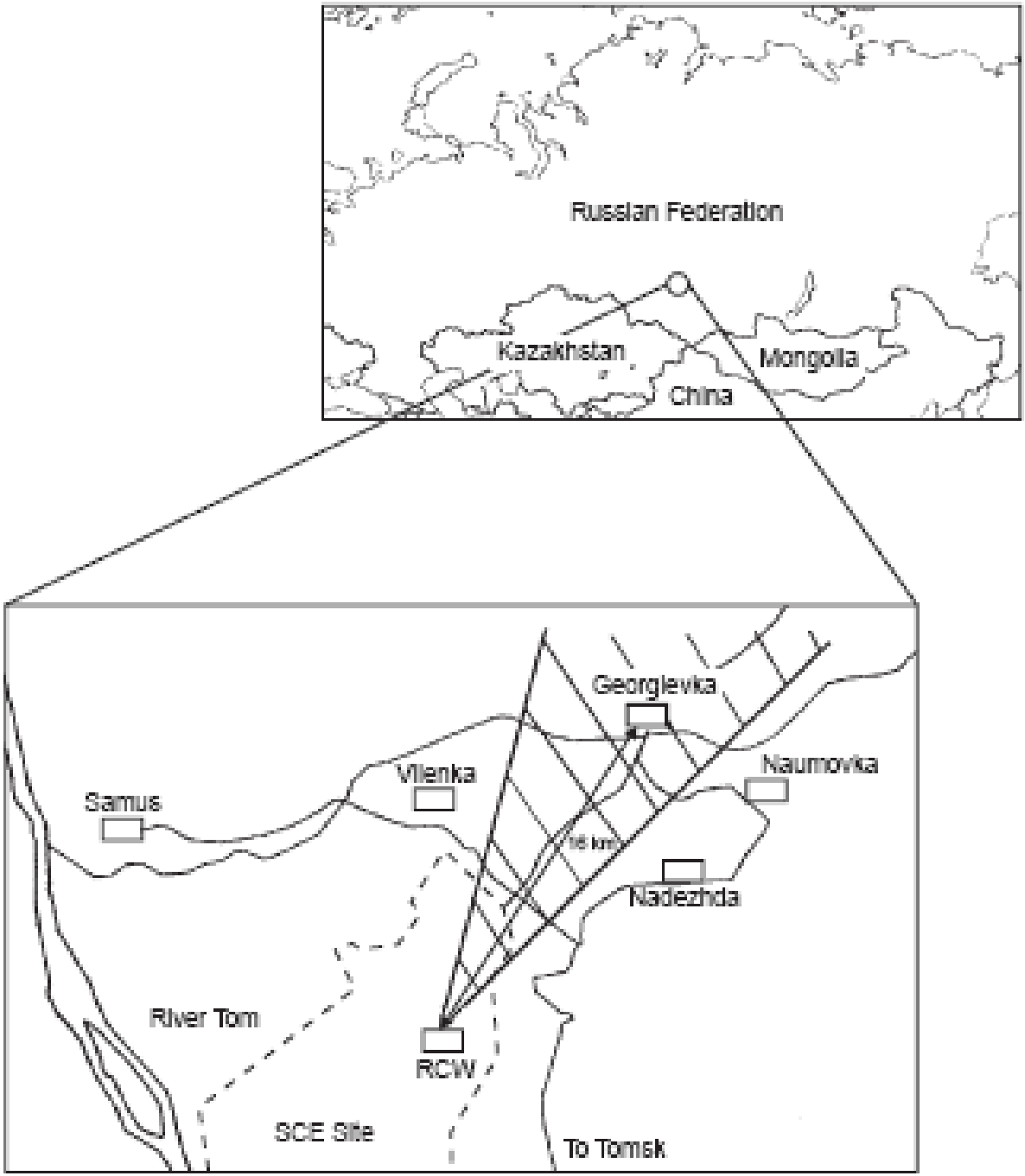
Some

radiation accidents in the

military complex

- On 6 April 1993
- Siberian Chemical Enterprises (SCE) facility near **Tomsk. Russian Federation**.
- The accident resulted in the release of about **30 TBq** of beta and gamma emitting radionuclides and about **6 GBq** of **^{239}Pu.**
- The SCE site and the surrounding countryside to the north, including the village of **Georgievka**, were contaminated.

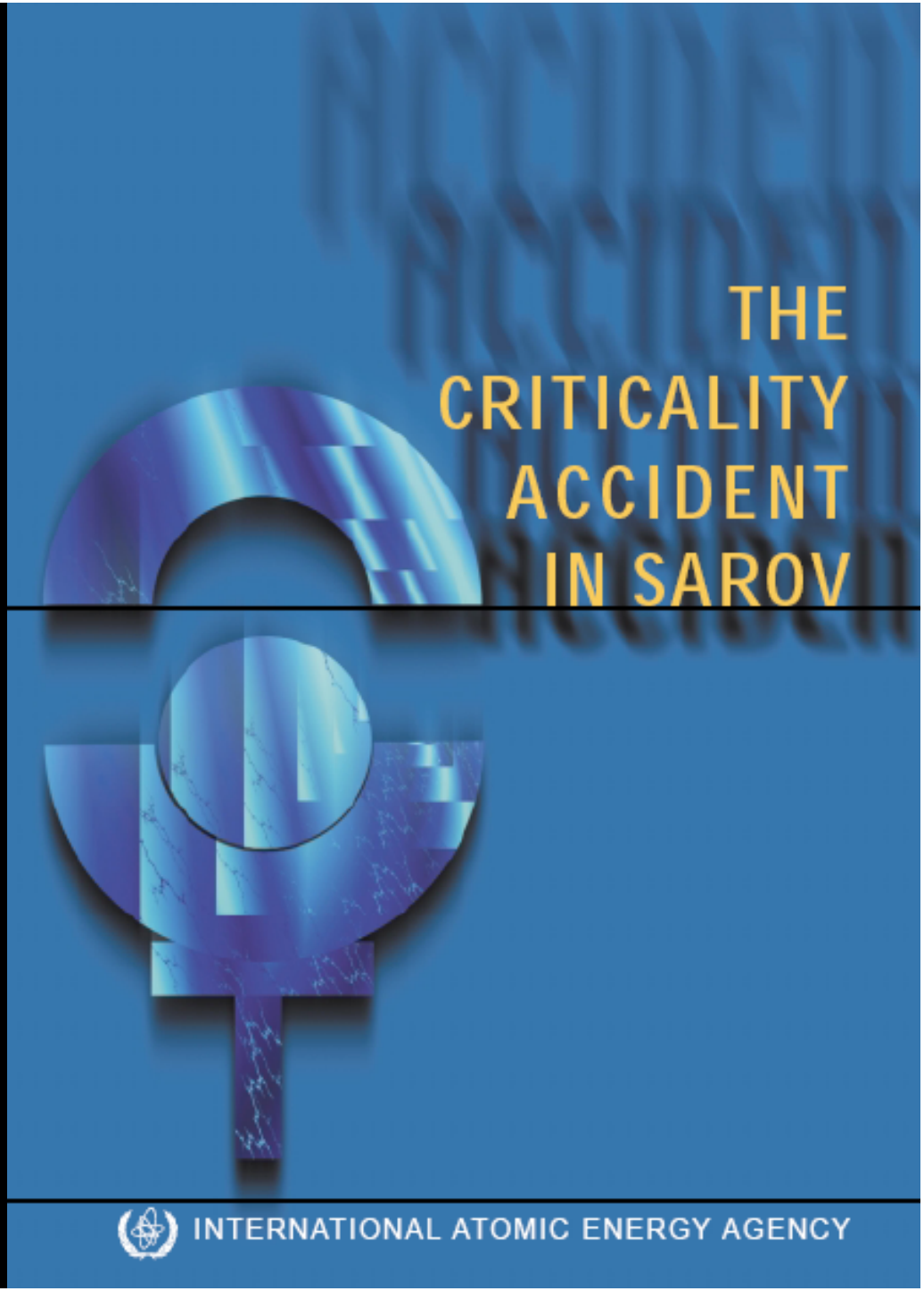



Russian Federation
Kazakhstan
Mongolia
China
Georgievka
Vilenka
Naumovka
Samus
16 km
Nadezhda
River Tom
RCW
SCE Site
To Tomsk

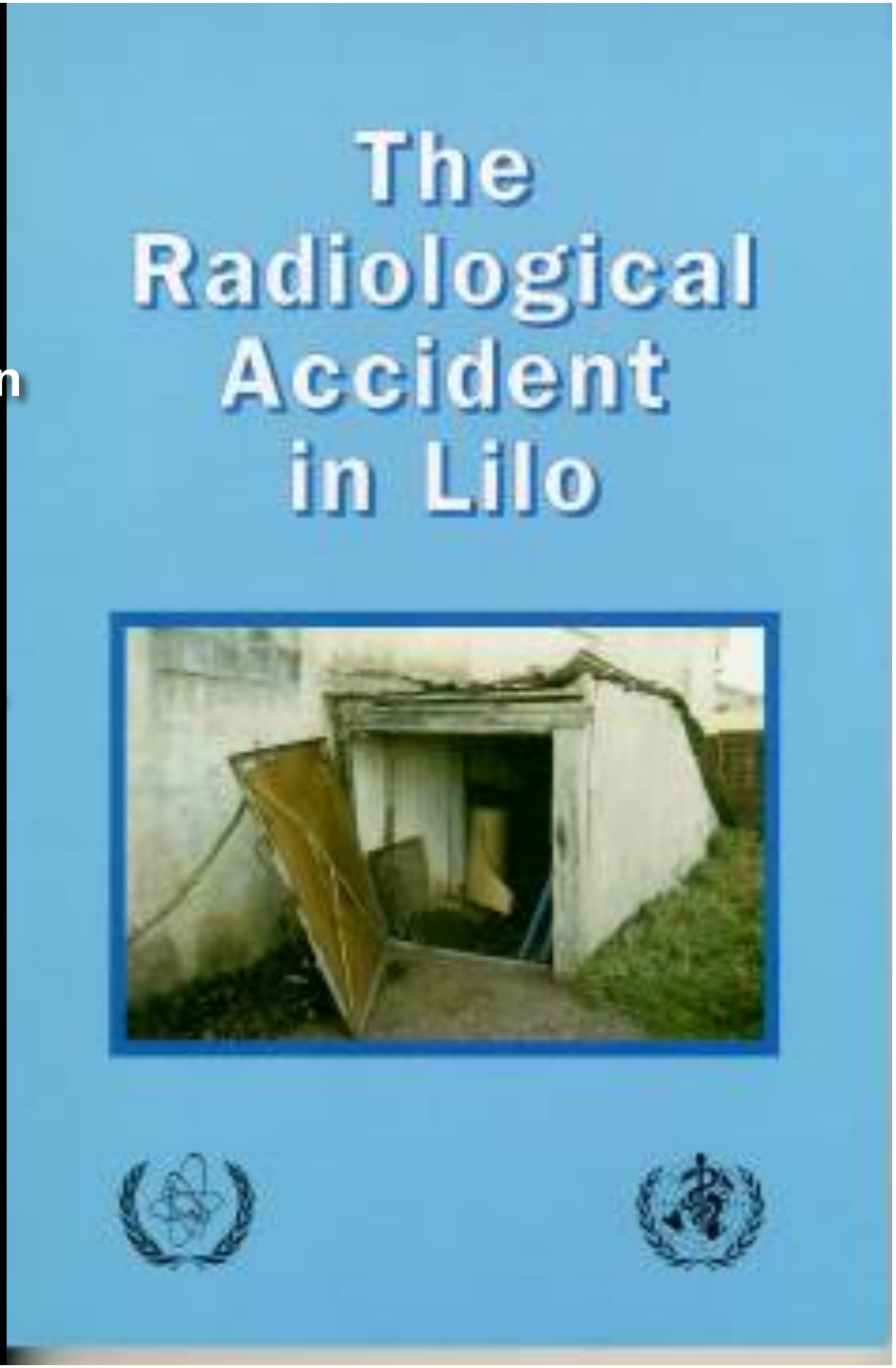
- On 21 October 1994,
- waste repository at Tammiku, Estonia,
- a metal container enclosing a caesium-137 source removed.
- source fell to the ground, it was picked up and placed it in a pocket and carried at home in the nearby village of Kiisa.

The Radiological Accident in Tammiku

- On 17 June 1997
- Russian Federal Nuclear Centre (formerly known as Arzamas 16) in the town of Sarov, near Nizhnij Novgorod, Russian Federation.
- Routine manipulation of the components of a critical assembly.
- Criticality accident
- Overexposed skilled technician, died 66 h later.



- 9 October 1997, Lilo, Georgia
- Servicemen of the Lilo Training Detachment of Frontier Troops developed local radiation induced skin diseases on various parts of their bodies.
- A large number of radiation sources, namely 12 137Cs sources, one 60Co source and 200 226Ra sources, were found abandoned in the premises, which previously had been used as barracks for troops from the USSR.



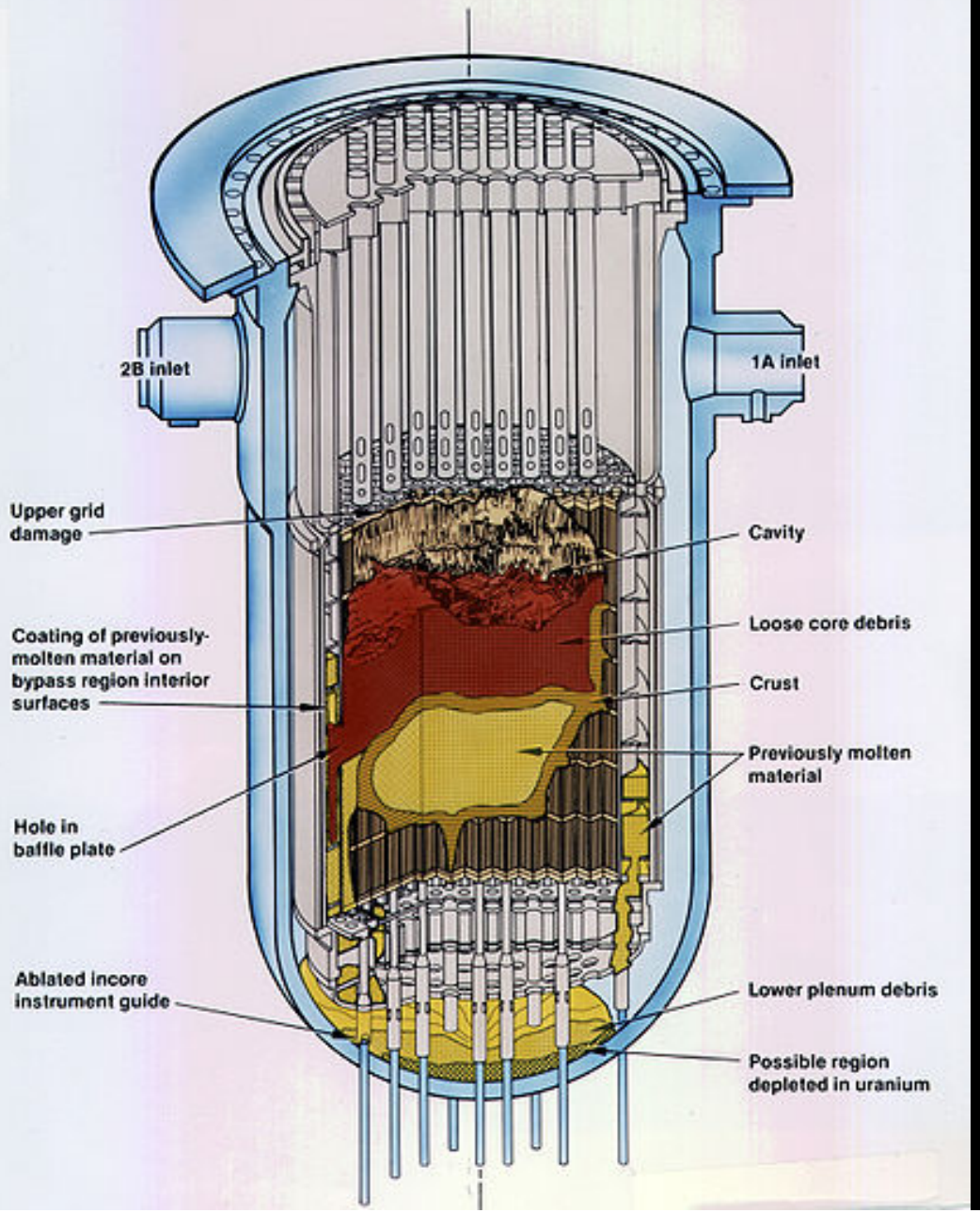
Part 2:

Nuclear accidents

- 3 nuclear accidents with public radiation exposure:
  - Three Mile Islands
  - Chernobyl
  - Fukushima
- Only Chernobyl had a measurable radiation health impact.

Three Mile Island NPP accident

TMI-2 Core End-State Configuration



Releases

6 10^{16} Bq, of noble gases
(Chernobyl: 7,0 10^{18}Bq)

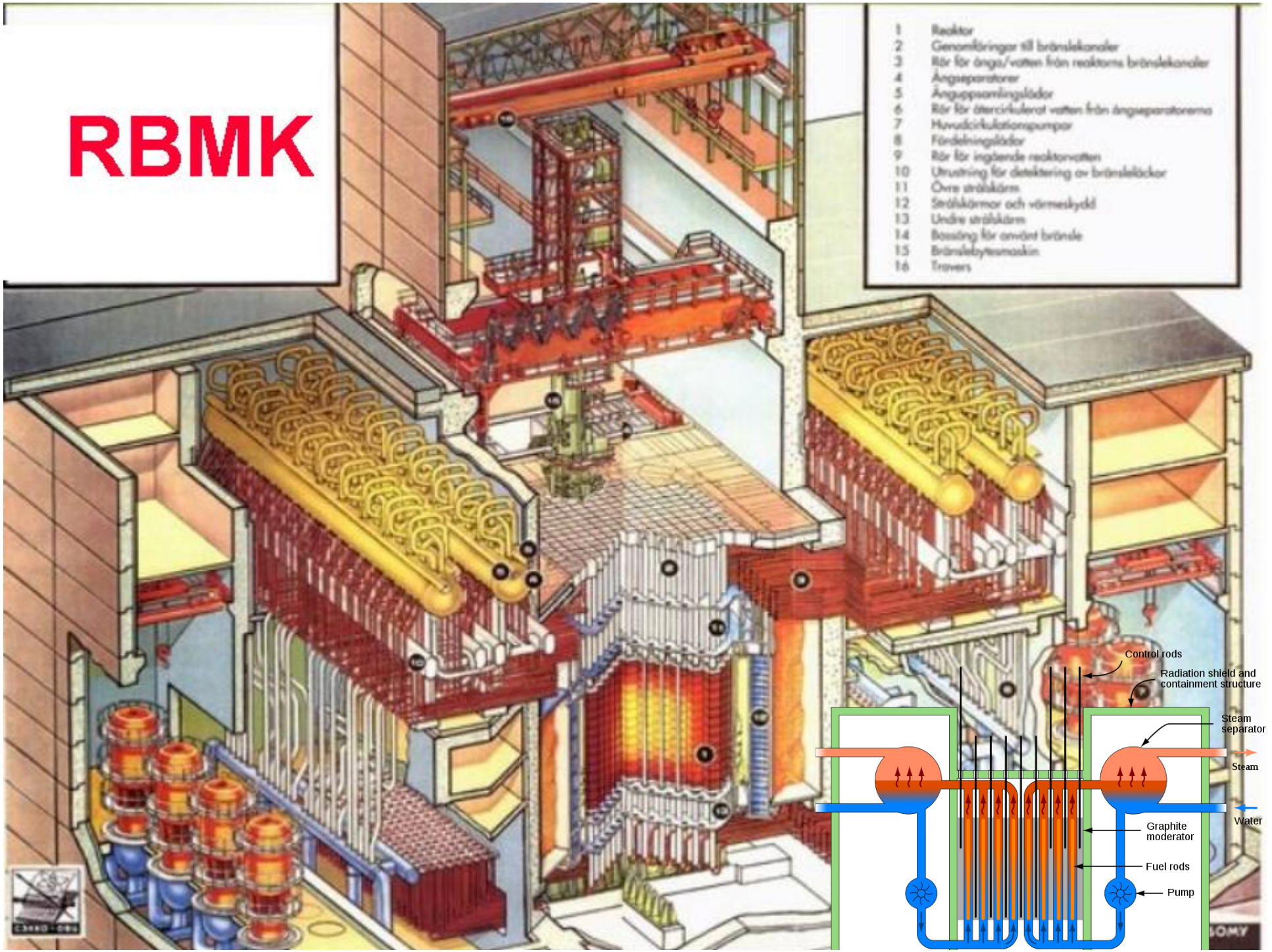
5 10^{11} Bq, of iodine-131
(Chernobyl: 3,2 10^{18} Bq)

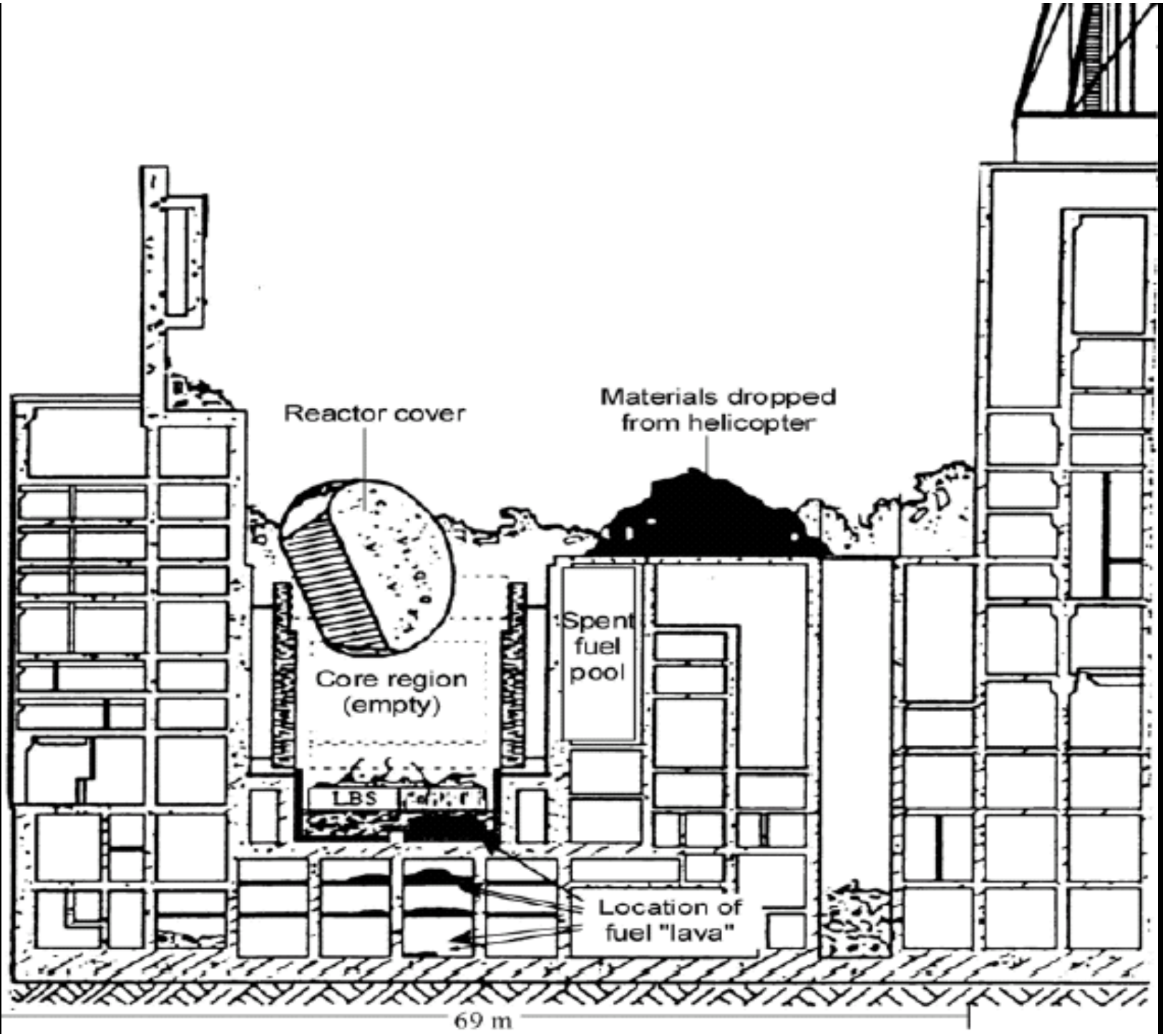
Consequences

- The dose to residents was much lower than the limits for normal operation.
- But, pregnant women and children in the county were evacuated (!?)
- People fell into panic.

Chernobyl Nuclear Power Plant Accident

RBMK


1 Reaktor
2 Genomföringar till bränslekanaler
3 Rör för ånga/vatten från reaktorns bränslekanaler
4 Ångseparatorer
5 Ånguppsamlingslådor
6 Rör för återcirkulerat vatten från ångseparatorerna
7 Huvudcirkulationspumpar
8 Fördelningslådor
9 Rör för ingående reaktorvatten
10 Utrustning för detektering av bränsleläckor
11 Övre strålskärm
12 Strålskärmar och värmeskydd
13 Undre strålskärm
14 Bassäng för använt bränsle
15 Bränslebytesmaskin
16 Traversen
Control rods
Radiation shield and containment structure
Steam separator
Steam
Water
Graphite moderator
Fuel rods
Pump

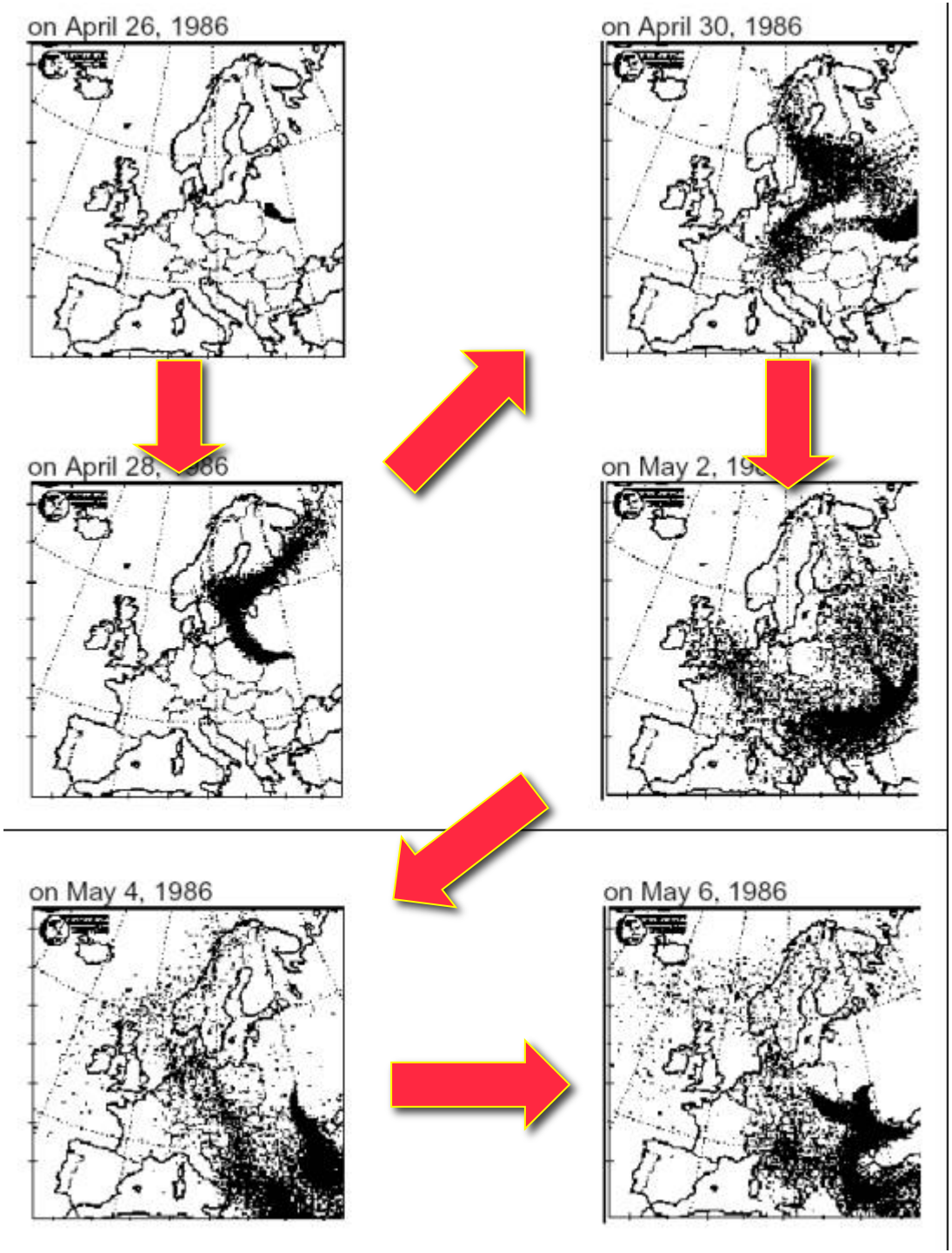

Reactor cover
Materials dropped from helicopter
Spent fuel pool
Core region (empty)
LBS
Location of fuel "lava"
69 m

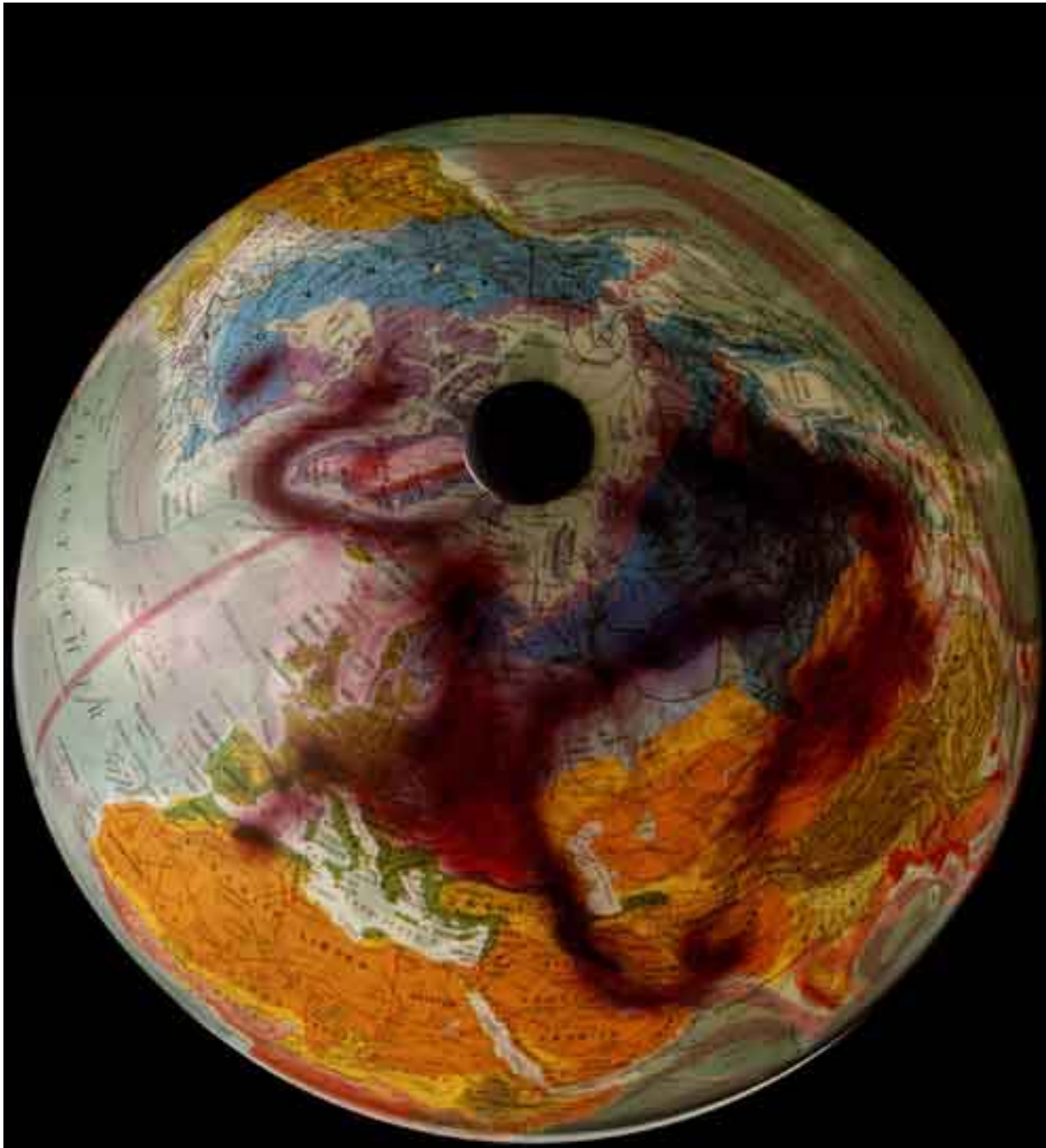
Radioactive discharge

$1.2\ 10^{19}$ Bq

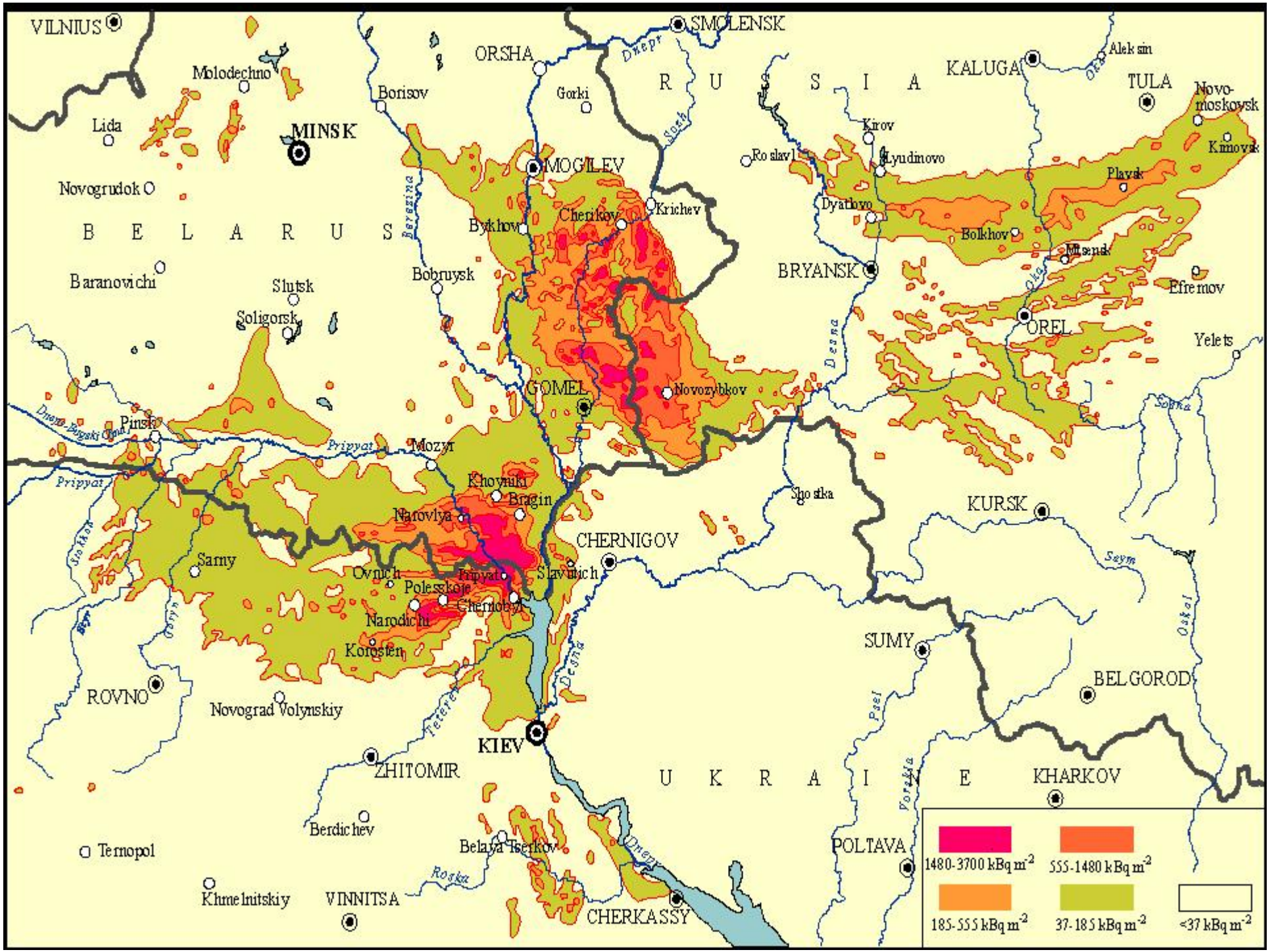
^{131}I	55%	(50 000 000 Ci)	$3,2\ 10^{18}$ Bq
^{134,137}Cs	33%		$4,0\ 10^{17}$ Bq
Noble gases:	100%		$7,0\ 10^{18}$ Bq

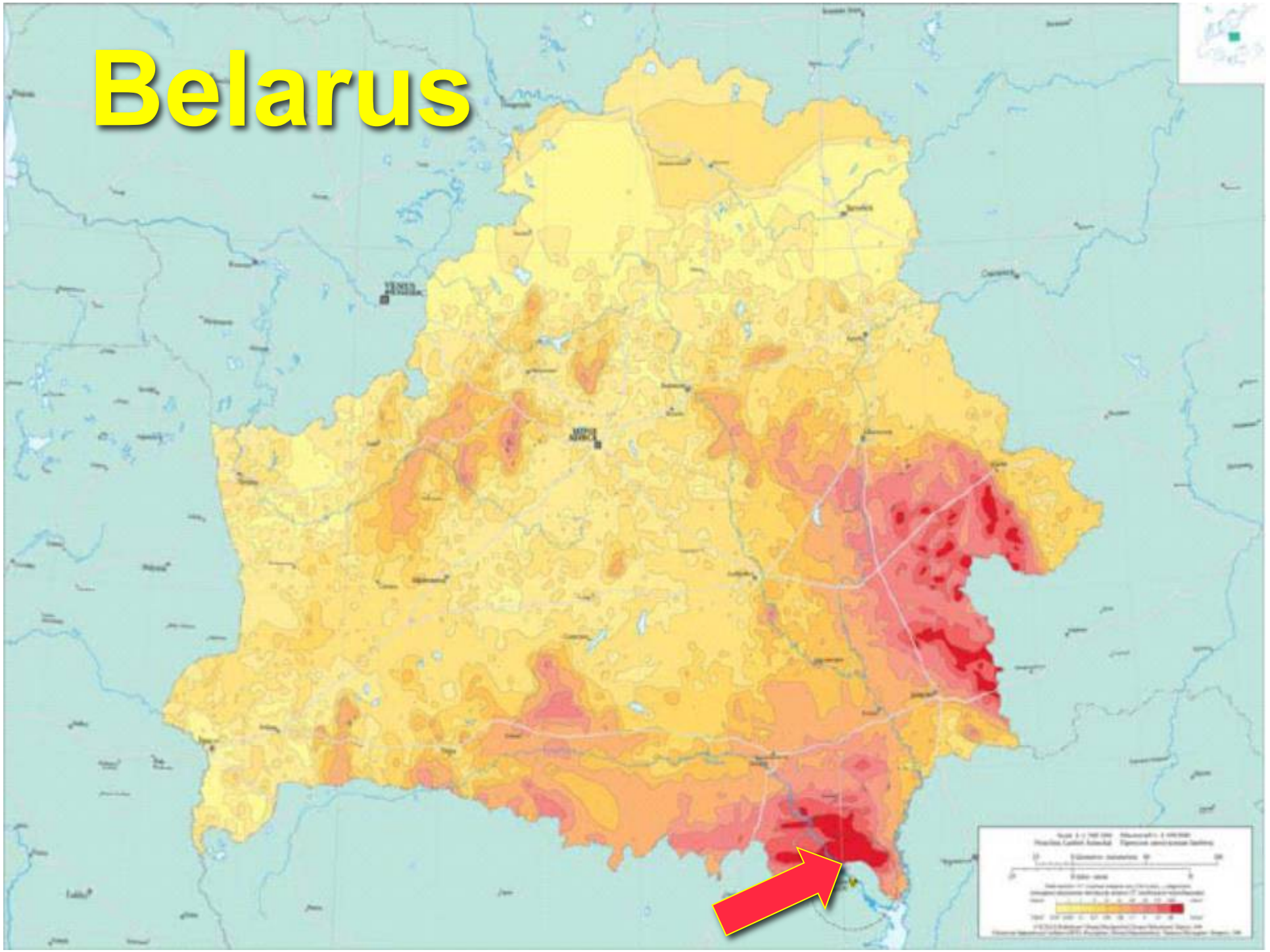
Atmospheric dispersion



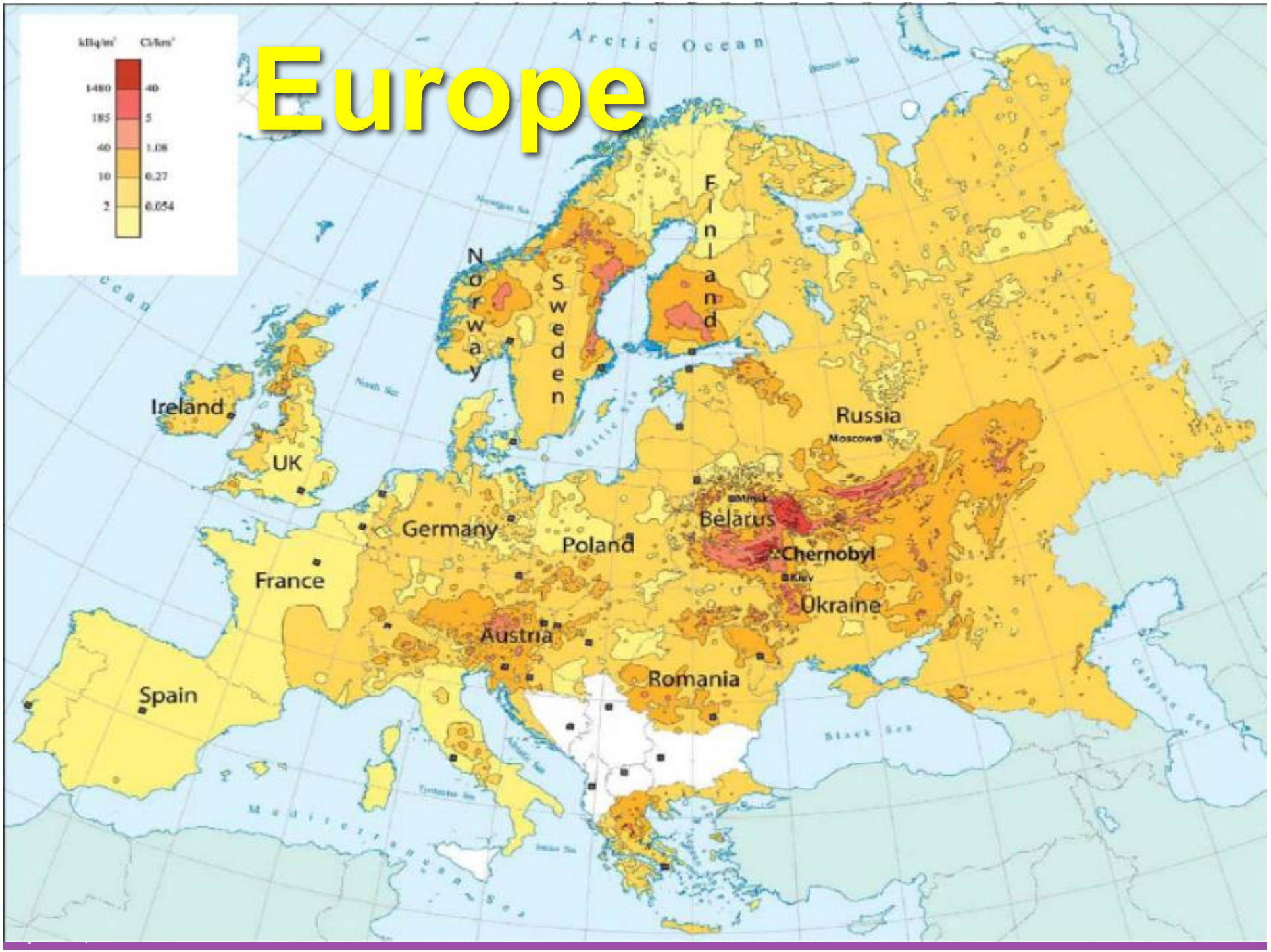


- The radioactive cloud dispersed over the entire northern hemisphere and deposited substantial amounts of radioactive material over large areas, contaminating land, water and biota and causing particularly serious social and economic disruption in Belarus, the Russian Federation and Ukraine.


VILNIUS
Molodechno
Lida
MINSK
Novogrudok
B E L A R U S
Baranovichi
Slutsk
Soligorsk
Pinsk
Dnepr-Bugski Kanal
Pripyat
Stokhod
Styr
Goryn
Sarny
ROVNO
Novograd Volynskiy
Ternopol
Khmelnitskiy
VINNITSA
Berdichev
ZHITOMIR
Teterev
KIEV
Roska
Belaya Tserkov
CHERKASSY
Dnepr
Desna
Ovruch
Polesskoje
Narodichi
Korosten
Chernobyl
Narovlya
Khoyniki
Bragin
Mozyr
GOMEL
Borisov
ORSHA
SMOLENSK
Gorki
Berezina
MOGILEV
Bykhov
Cherikov
Krichev
Bobruysk
Novozybkov
Dnepr
R U S S I A
Desna
Sozh
Roslavl
Kirov
Lyudinovo
Dyatkovo
BRYANSK
Bolkhov
Mtsensk
Oka
OREL
Efremov
Yelets
Snovsk
Sosna
KALUGA
Aleksin
Oka
TULA
Novo-moskovsk
Kimovsk
Plavsk
Shostka
KURSK
Seym
Psel
SUMY
BELGOROD
Oskol
Vorskla
POLTAVA
KHARKOV
U K R A I N E
1480-3700 kBq m-2
555-1480 kBq m-2
185-555 kBq m-2
37-185 kBq m-2
<37 kBq m-2


Belarus


Ukraine
Black Sea
Sea of Azov


Europe
kBq/m²
Ci/km²
1480
185
40
10
2
40
5
1.08
0.27
0.054
Arctic Ocean
Norway
Sweden
Finland
Ireland
UK
Germany
France
Spain
Poland
Belarus
Russia
Moscow
Chernobyl
Ukraine
Austria
Romania
Black Sea

Radiation Health Effects of the Chernobyl Accident

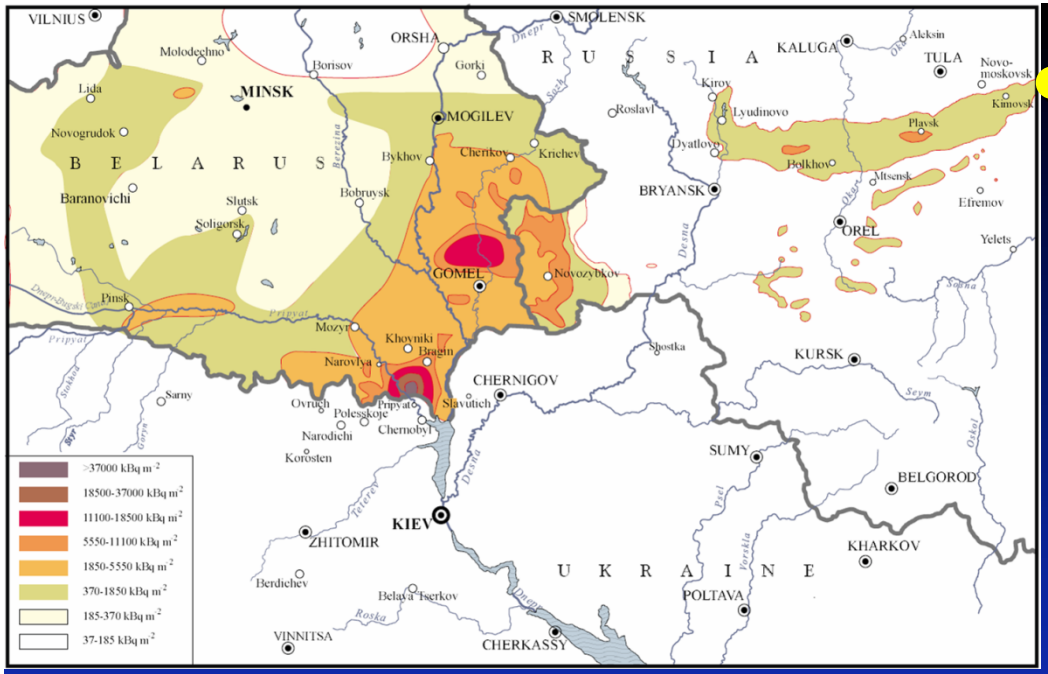
- ✓ **30 rescuers died** (28 with acute radiation syndrome)
- ✓ **Few 100 rescuers were injured**
- ✓ **Around 7000 children-thyroid cancers reported** (in Belarus, the Russian Federation, and Ukraine)
- ✓ **No detectable increases of other cancers (incidence or mortality),** which can be attributed to radiation from Chernobyl.

Essentially, the Chernobyl's victims were:

1. children exposed to radioiodine and
2. the emergency workers

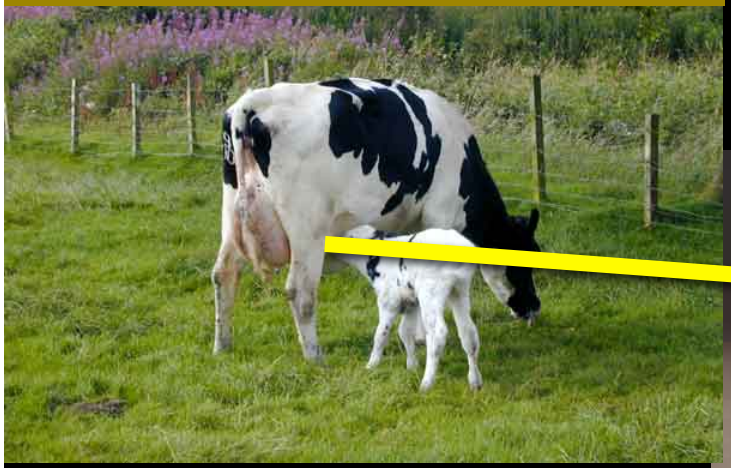
1. Children

Thyroid cancers



- **A substantial increase in thyroid cancer incidence among persons exposed to the accident-related radiation as children or adolescents in 1986 has been observed in Belarus, Ukraine and four of the more affected regions of the Russian Federation.**

Figure 29-9. Fallout.



For the period 1991-2005, more than 6,000 cases were reported, of which a substantial portion could be attributed to drinking milk in 1986 contaminated with iodine-131.

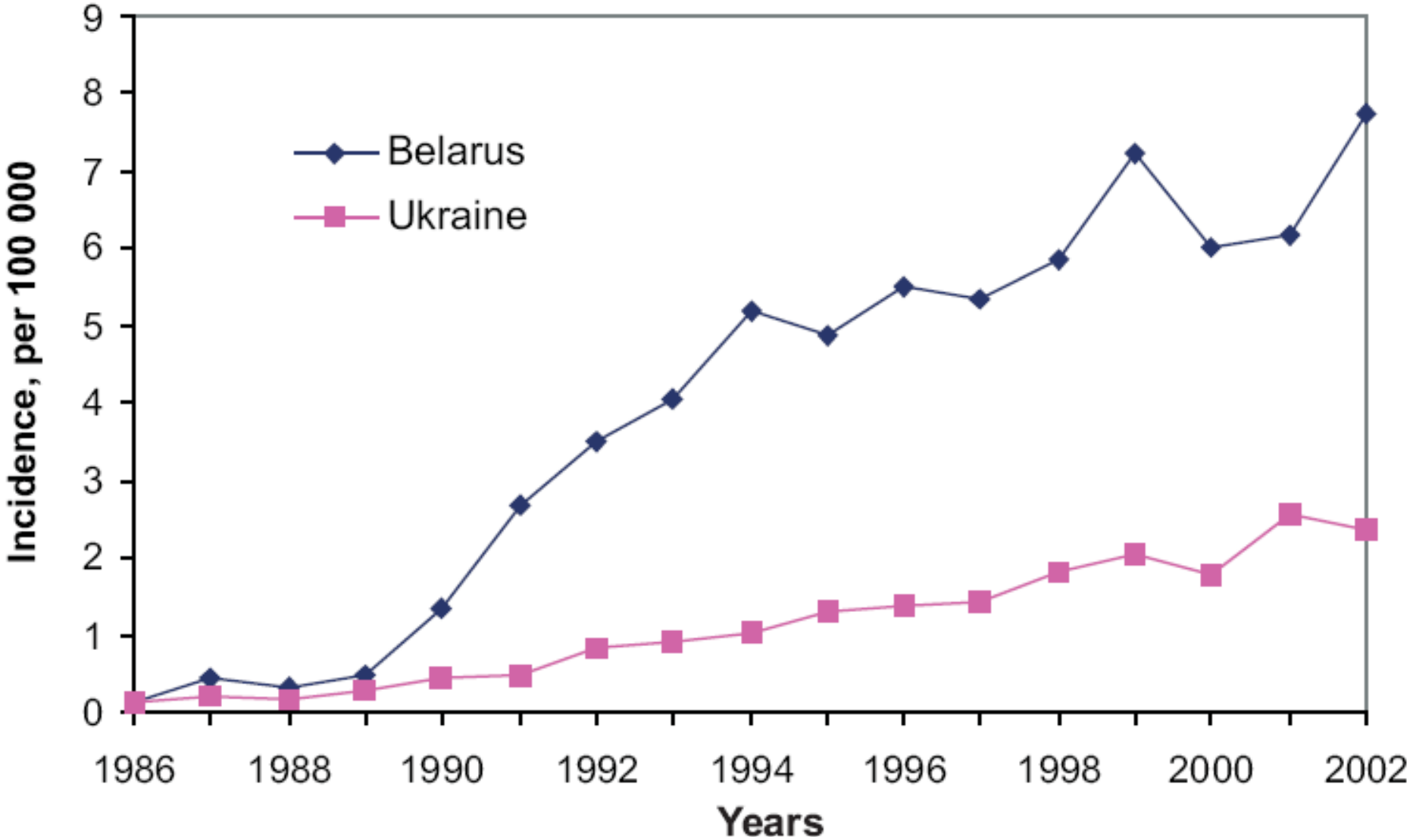
high doses

?

- - Average 300 mSv ?
- – Higher 10000 mSv ?

more?

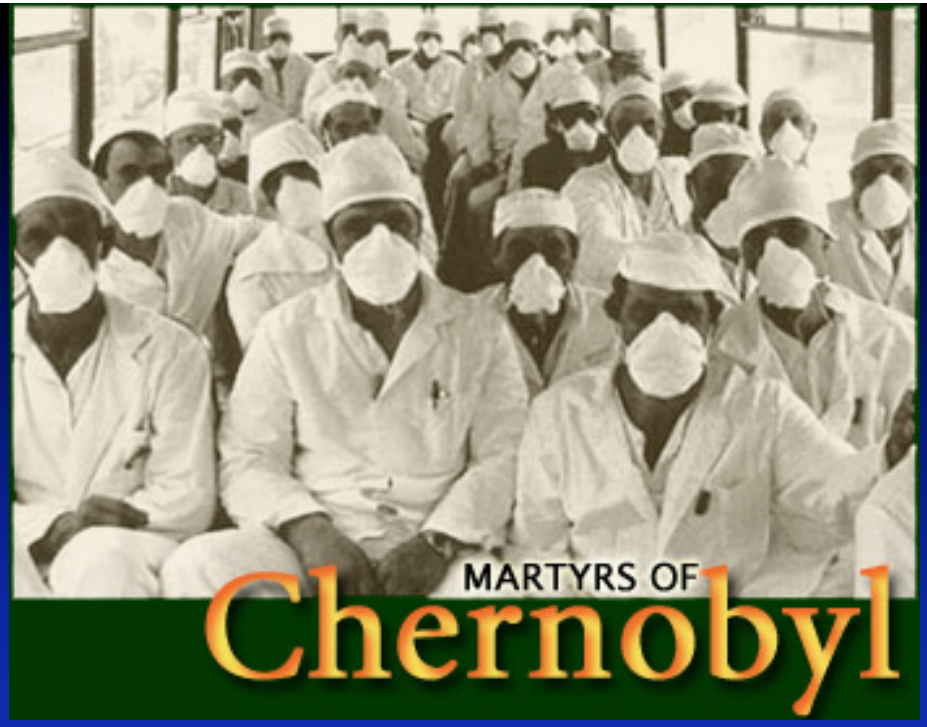
Although several thousands of extra thyroid cancer cases occurred only 15 were fatal



Incidence rate of thyroid cancer in children and adolescents exposed to 131I as a result of the Chernobyl accident (after Jacob et al., 2005)

2. Workers

Two workers died in the immediate aftermath, and 134 plant staff and emergency personnel suffered acute radiation syndrome, which proved fatal for 28 of them.



admitted in hospital : 237

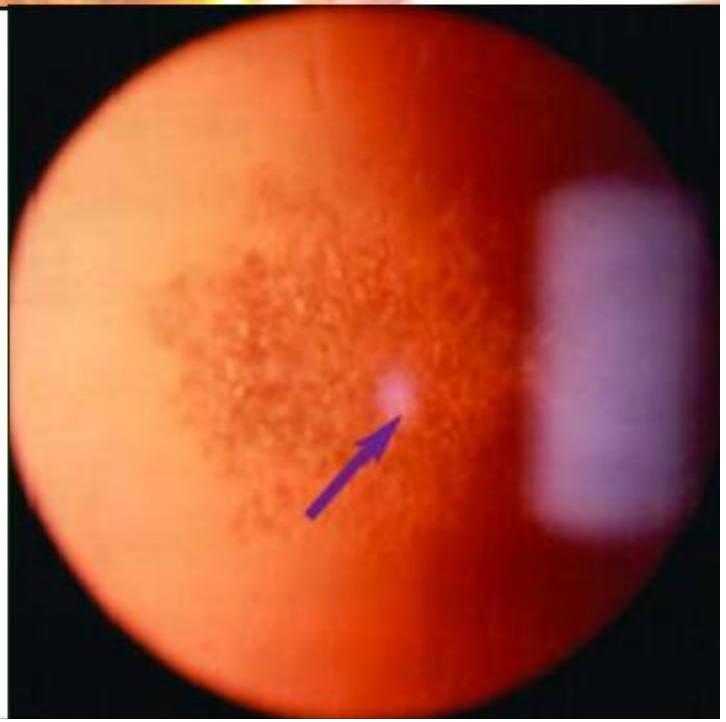
diagnosed with ‘acute radiation syndrome :134

Hospital 6; Moscow

The high radiation doses proved fatal for 28 of those people in the first few months following the accident.

Skin injuries and radiation-related cataracts were among the main sequelæ of ARS survivors;

18. Patient A (Day 26): burns to the legs and feet.



Several hundred thousand workers were subsequently involved in recovery operations.

Among the several hundred thousand people were involved in recovery operations **there is no evidence of health effects that can be attributed to radiation exposure.**

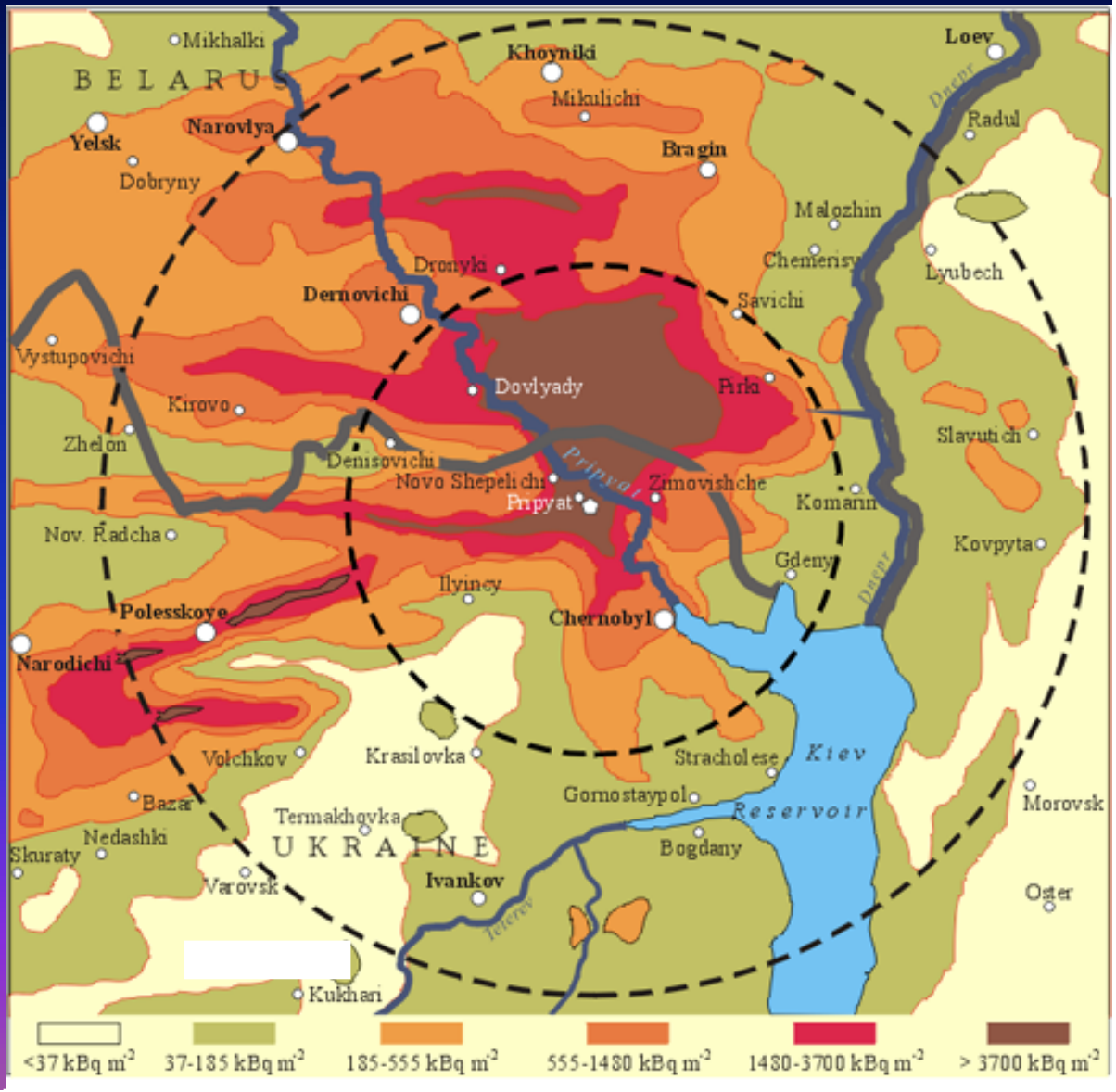

MARTYRS OF
Chernobyl

Public exposure

Evacuation and resettlement

How many?

Ucrania	91,406
Belarus	24,725
Russia	186
Total	**116,317**




Прип'ять
Pripyat


Энергетик

Most area residents were exposed to low-level radiation comparable to or a few times higher than the annual natural background radiation levels.

Long-term public radiation doses

- The long-term radiation doses were low.
- The average additional dose over all the period 1986-2005 was 9 mSv.
- This is approximately equivalent to that from a CT.

No evidence of any health effect that can be attributed to radiation exposure.

1. These conclusions should not be construed to underplay the Chernobyl tragedy.
2. It should be underlined that the Chernobyl accident is also responsible for:

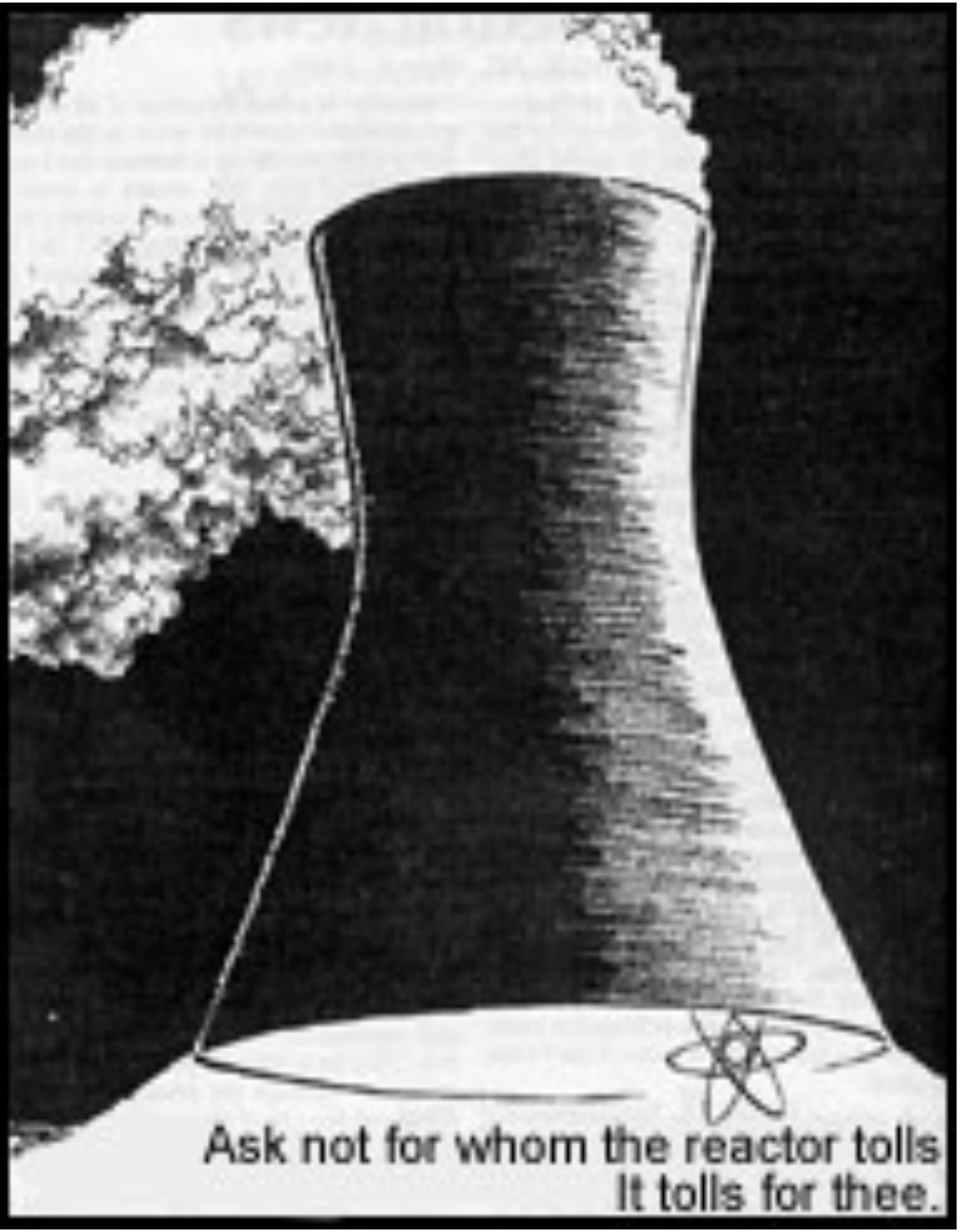
A political cataclysm

A social tragedy

The economic collapse of the region

Serious psychological effects

Chernobyl mithology




Miss Tchernobyl 2002
binnes.com

Fukushima Nuclear Power Plant Accident

Fukushima Dai-ichi NPP

What happened?

(1) Earthquake

- An old nuclear power plant, with outdated safety features, was hit by a catastrophic earthquake that devastated whole cities.
- Nevertheless, the plant was not significantly damaged and shut down safely.

(2) Black-out

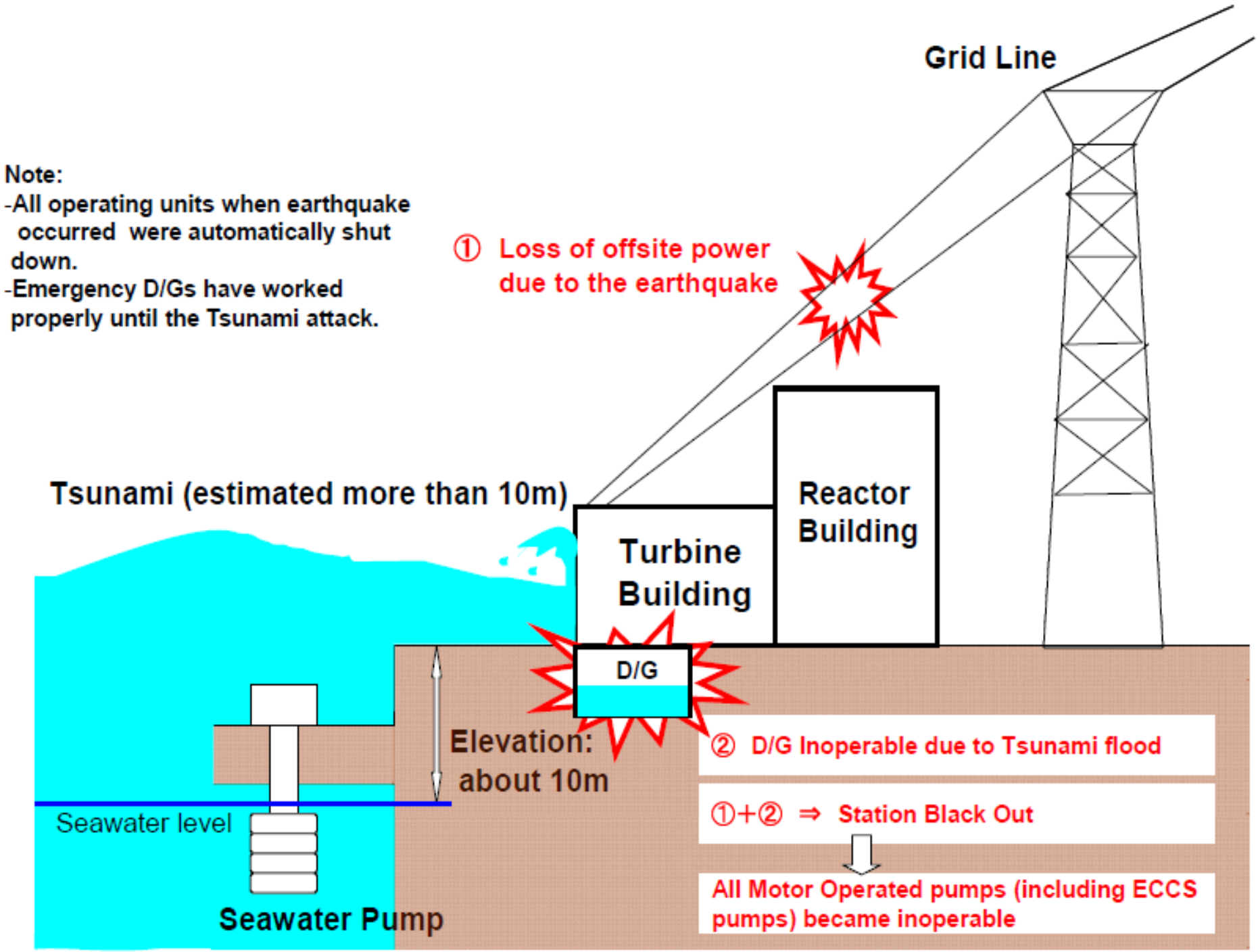
- However, the earthquake also destroyed the electrical power lines of the entire area.
- Notwithstanding, an emergency power system replaced the normal power supply and the decay heat could be removed.

(3) Tsunami

- But a large tsunami of 14 meters, flooded the area, killed more than 30000 people, and suppressed the emergency cooling.


重油9


ンプール水サージタン
500KL

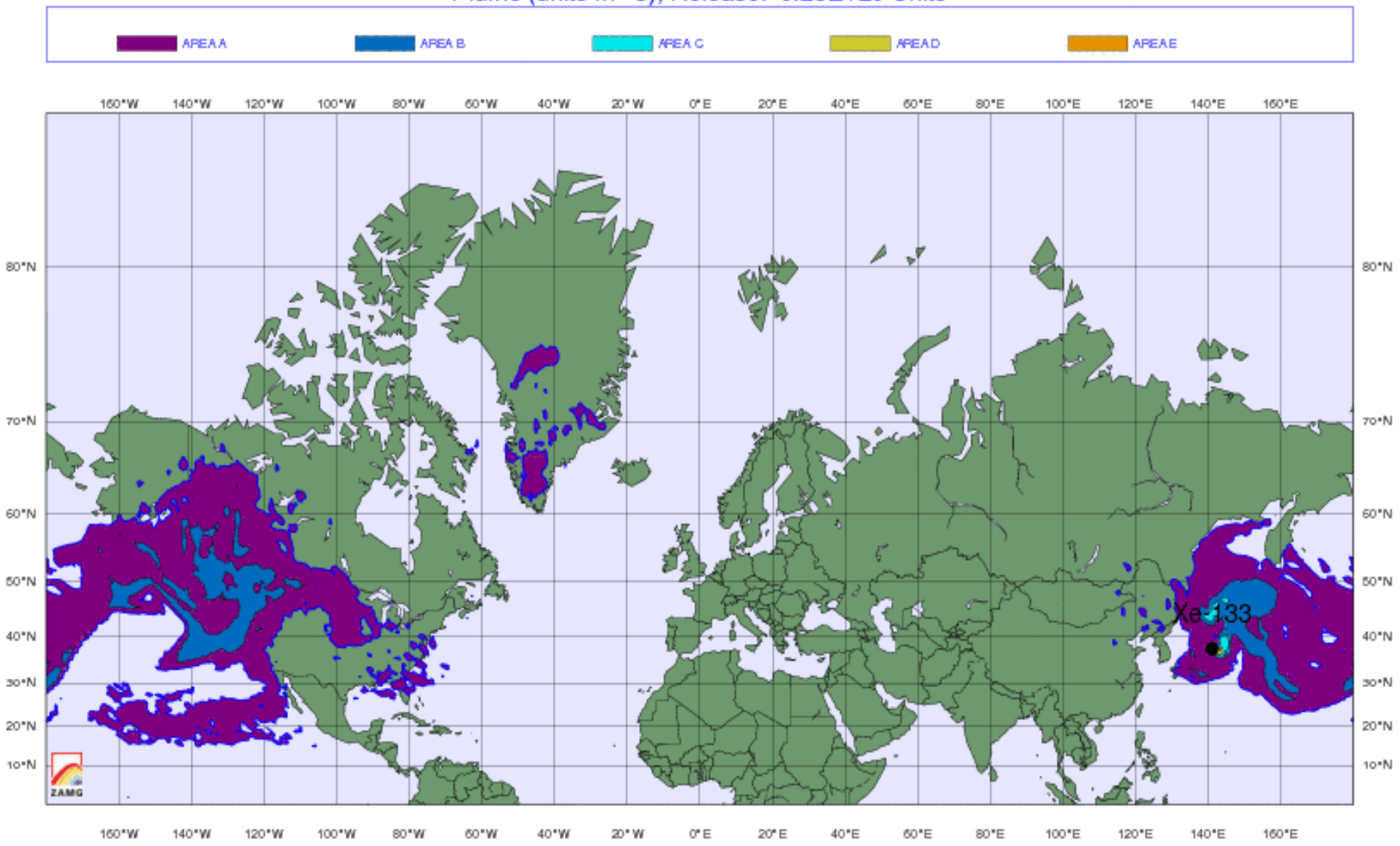

Note:
-All operating units when earthquake occurred were automatically shut down.
-Emergency D/Gs have worked properly until the Tsunami attack.
Grid Line
① Loss of offsite power due to the earthquake
Tsunami (estimated more than 10m)
Turbine Building
Reactor Building
D/G
Elevation: about 10m
Seawater level
Seawater Pump
② D/G Inoperable due to Tsunami flood
①+② ⇒ Station Black Out
All Motor Operated pumps (including ECCS pumps) became inoperable

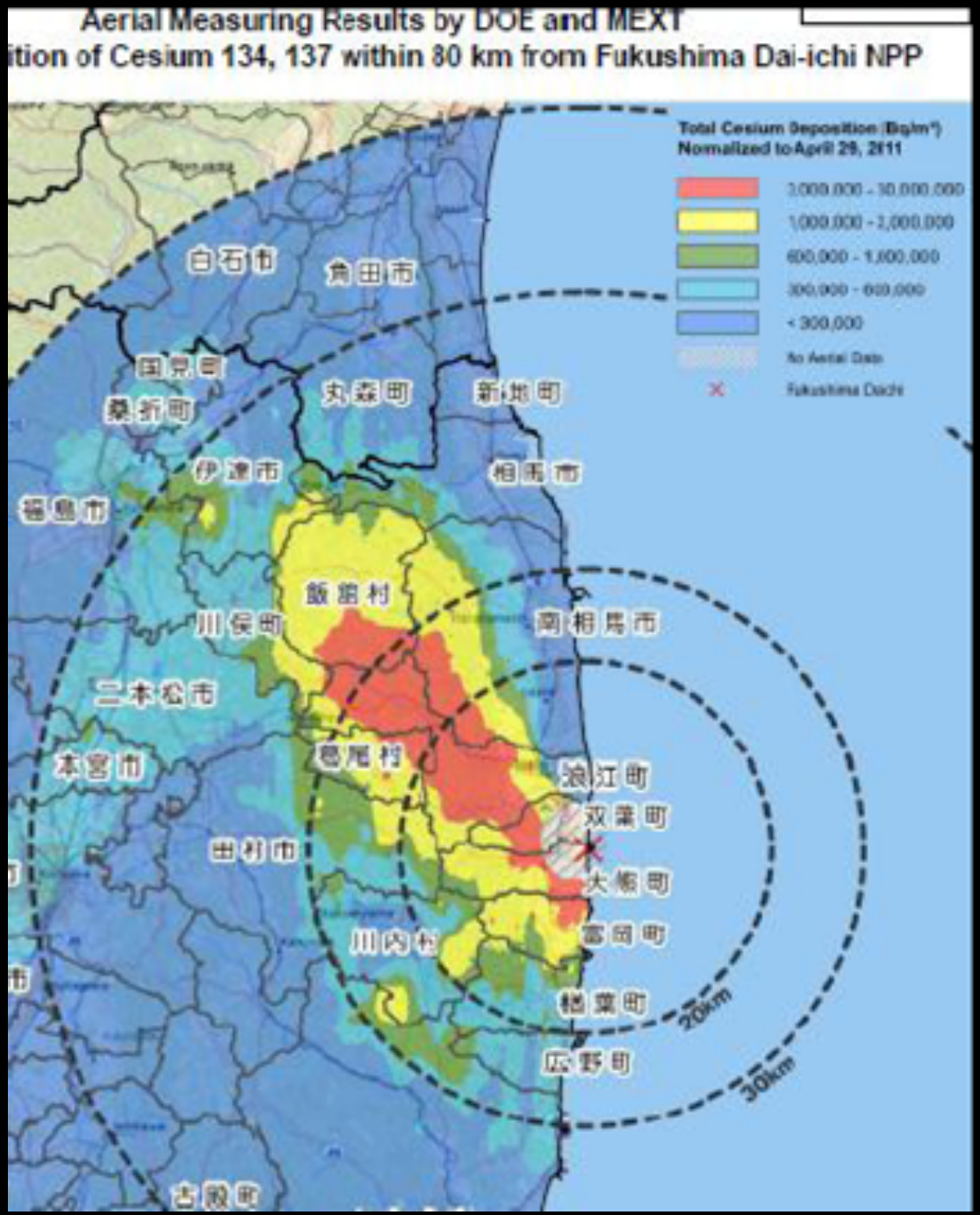
Consequences

- Part of the reactor fuel was melted down.
- The containment was inadequate, and large amounts of radioactive materials were released into the environment.

Inadequate containment

AKW_FUKUSHIMA-Xe-133
20110508-000000
Plume (units m^-3), Release: 0.25E+20 Units





April 2nd, 2013

Yet, in spite of this amazing scenario, nobody received a lethal dose of radiation!

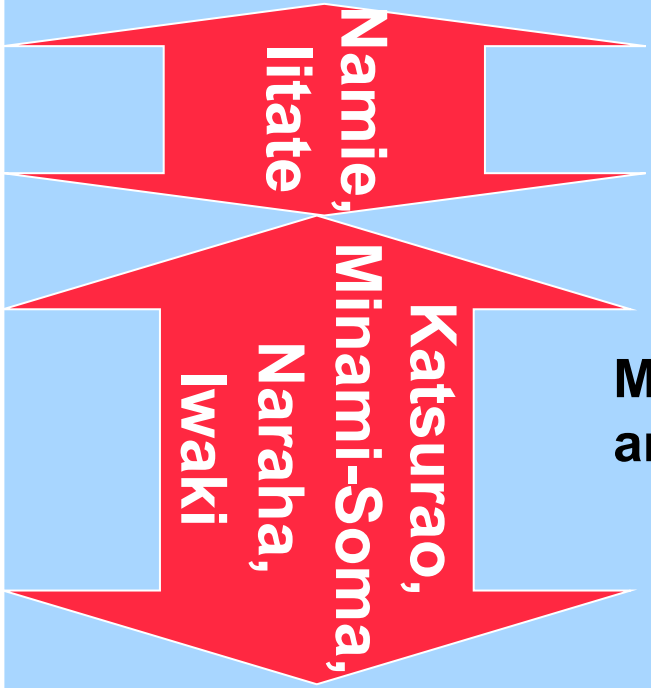
Preliminary dose estimation

from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami

World Health Organization

Natural Background

annual dose
mSv/year



Few people
In few areas ⇒ ~100

VERY HIGH

Many people
In many areas ⇒ ~ 10

TYPICALLY HIGH

Majority of people
around the world ⇒ ~ 2.4

AVERAGE

~ 1

MINIMUM

The main lesson from Fukushima

- **Fukushima destroys a nuclear myth: that nuclear accidents will not happen.**
- **Accidents happen and will continue to occur**
- **‘*Maximum credible accidents*’ are illusions**

Fukushima confirmed:

- the dominance of

  the *unpredictable*

over

- the *unlikely* but *foreseeable*.

THE BLACK SWAN

The Impact of the HIGHLY IMPROBABLE

Nassim Nicholas Taleb

Mitigation!

- It should be accepted that

  - however robust the prevention is -

  there is always the possibility of implausible unpreventable events…and… in our view,

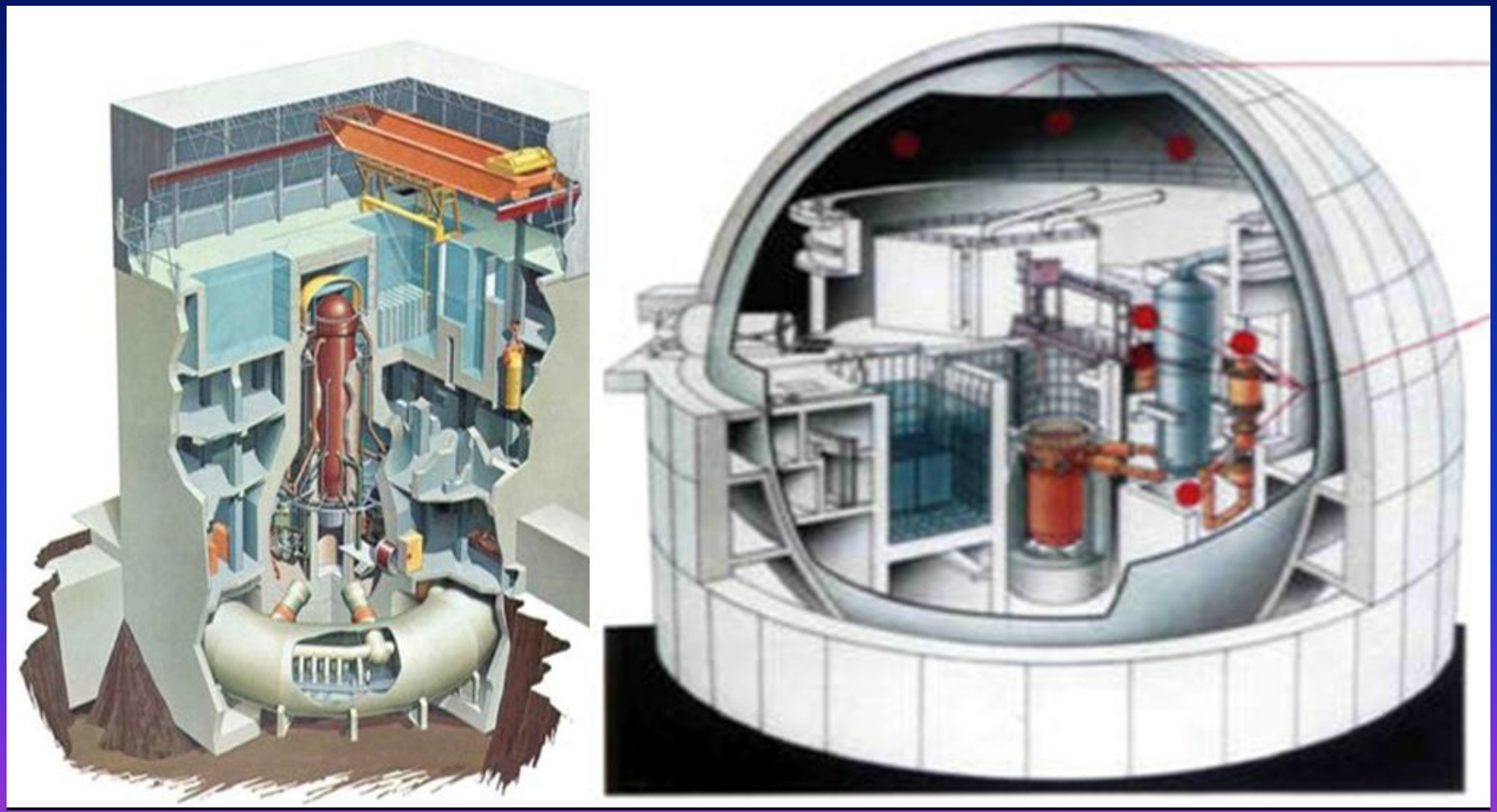
  …mitigation should therefore became paramount for nuclear safety

What *mitigation* means

1. **Containing** radioactivity to reduce releases

2. **Protecting people** to reduce doses

Containment



IAEA SAFETY STANDARDS SERIES

Preparedness and Response for a Nuclear or Radiological Emergency

JOINTLY SPONSORED BY
FAO, IAEA, ILO, OECD/NEA, PAHO, OCHA, WHO

REQUIREMENTS

No. GS-R-2

INTERNATIONAL
ATOMIC ENERGY AGENCY
VIENNA

Radiation Protection lessons learned from Fukushima

(A report of ICRP Task Group 84)

1. Misuse
of
nominal risk coefficients

The Canadian
www.agoracosmopolitan.com

Death toll from Japan nuclear catastrophe could top 500,000

DATE: 13 AUGUST 2011 POSTED BY : SPECIAL TO THE CANADIAN

John H. Large has been reported as having predicted that the death toll in the years ahead could top the 500,000 attributed to the Chernobyl accident of 1986 and warned that panicked repair attempts could lead to an even greater disaster. Mr. Large, a British nuclear engineer, said: "The Japanese don't know how to deal with it. They're ad-libbing.

"Just throwing water on to the reactors, when they cannot get inside to see what the situation is, could mean the fuel goes critical again.

"And while the radiation leak so far is only a tenth of that at Chernobyl, that was in a rural area with a low population. In Japan it's an urban, densely packed area so the potential numbers of deaths and cancers are much higher."

Mr. Large is an independent nuclear engineer and analyst primarily known for his work in assessing and reporting upon nuclear safety and nuclear related accidents.[LINK] From the mid-1960s until 1986 Large was an academic in Brunel University's School of Engineering, where he undertook research for the United Kingdom Atomic Energy Authority.

Mr. Large prepared a critical review of the preliminary report of the IAEA Fact Finding Mission undertaken to Fukushima Dai-ichi in May 2011. [LINK][LINK]

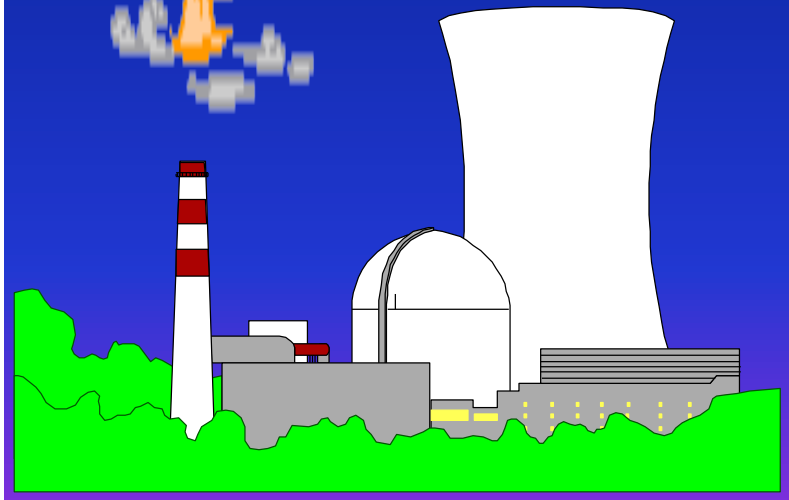
Blog | Books | Latest | Culture

- Manipulative Extraterrestrials control Earth suggests Dr. Michael Salla
- Humanized face of aliens control Earth suggests Dr. Michael Salla
- Perpetuated War and Canada's First Nations
- Toronto Housing Project linked to


Will I be one of the 500.000?

What is the problem?

Modeling



Discharges

Collective doses

Collective Dose x Nominal Risk Coefficient = Nominal Deaths

X 5%/Sv =

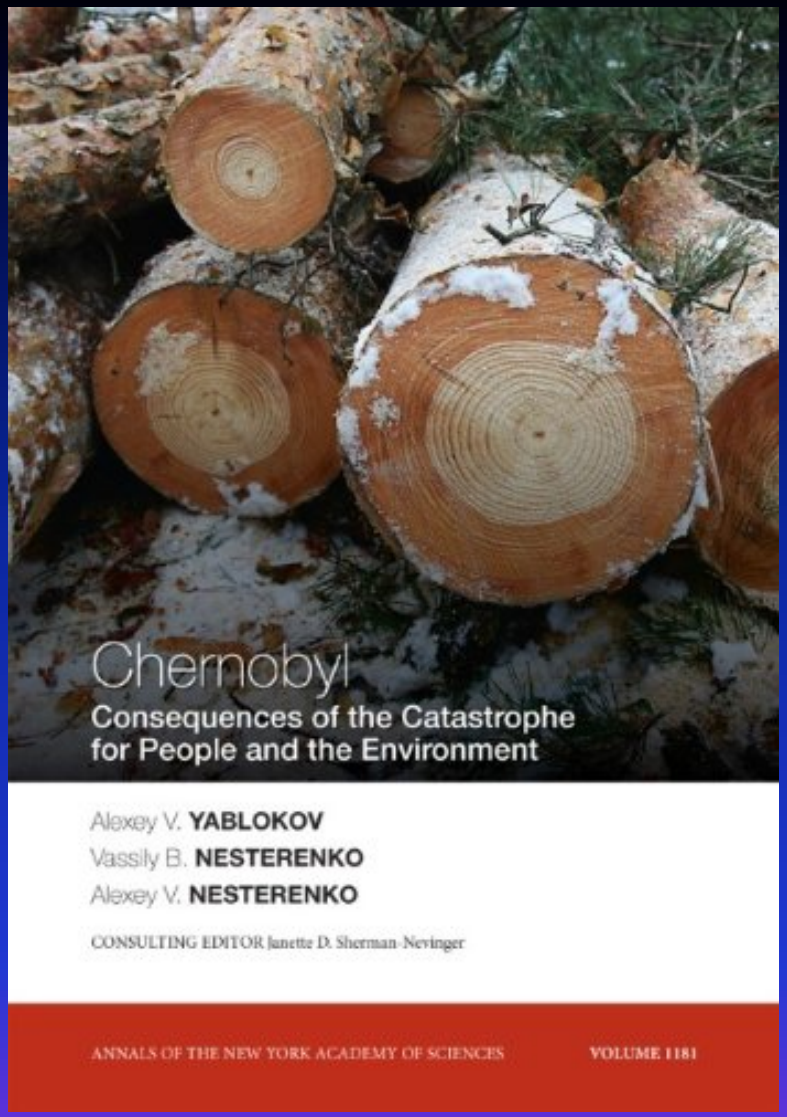
March 25, 2006 Saturday

SECTION: GUARDIAN INTERNATIONAL PAGES; Pg. 17

HEADLINE:

UN ignores 500 000 Chernobyl deaths

IAEA says will be less than 4 000



Chernobyl:

Consequences of the Catastrophe for People and the Environment

Annals

of the

New York Academy of Sciences

Alexey V. Yablokov (Editor),
Vassily B. Nesterenko (Editor),
Alexey V. Nesterenko (Editor),
Janette D. Sherman-Nevinger (Editor)

It concludes that based on records now available,

some 985,000 people died of cancer caused by the Chernobyl accident!

Hope

UNSCEAR:
Report to the UN General Assembly

A/67/46

United Nations

Report of the United Nations Scientific Committee on the Effects of Atomic Radiation

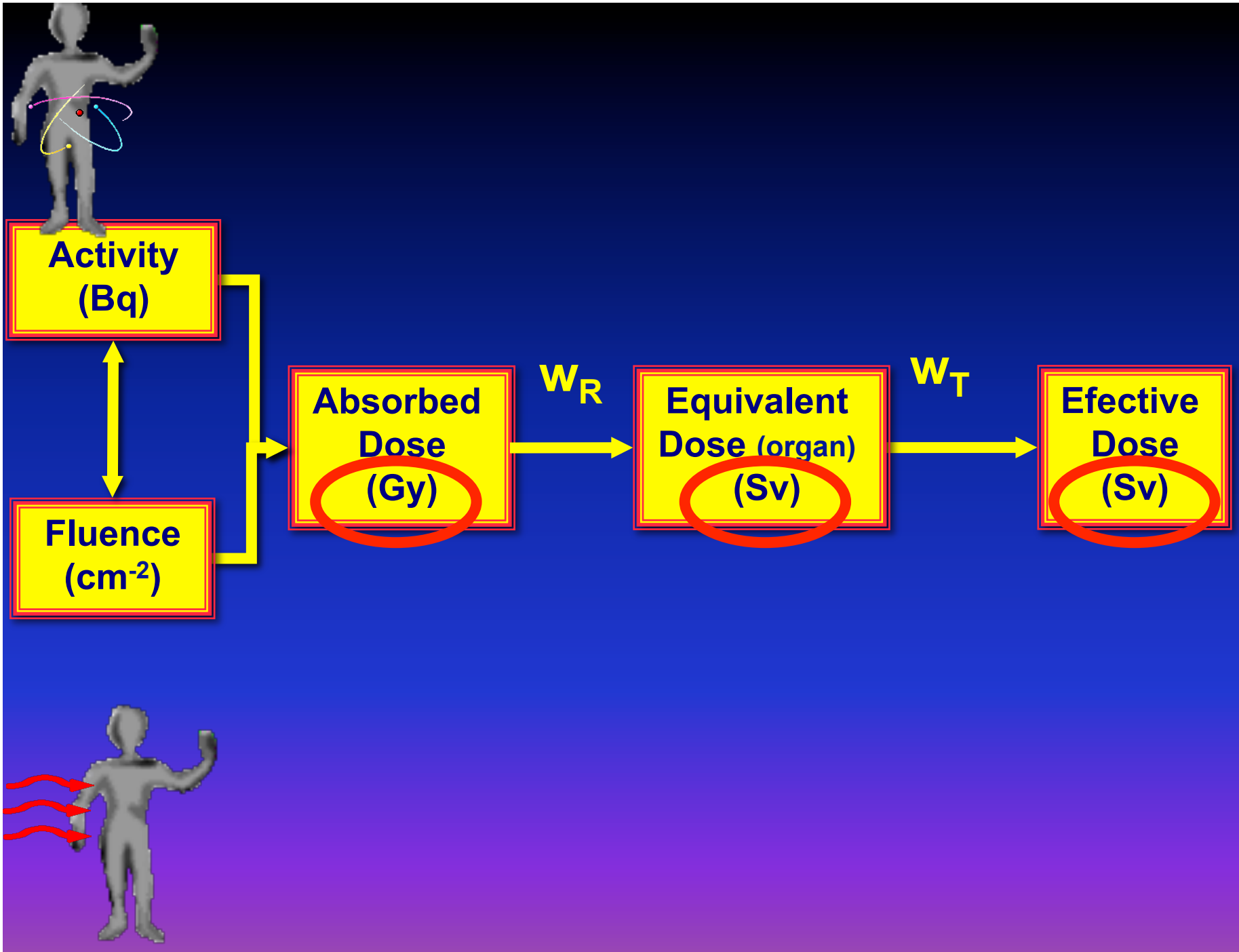
Fifty-ninth session
(21-25 May 2012)

General Assembly
Official Records
Sixty-seventh session
Supplement No. 46

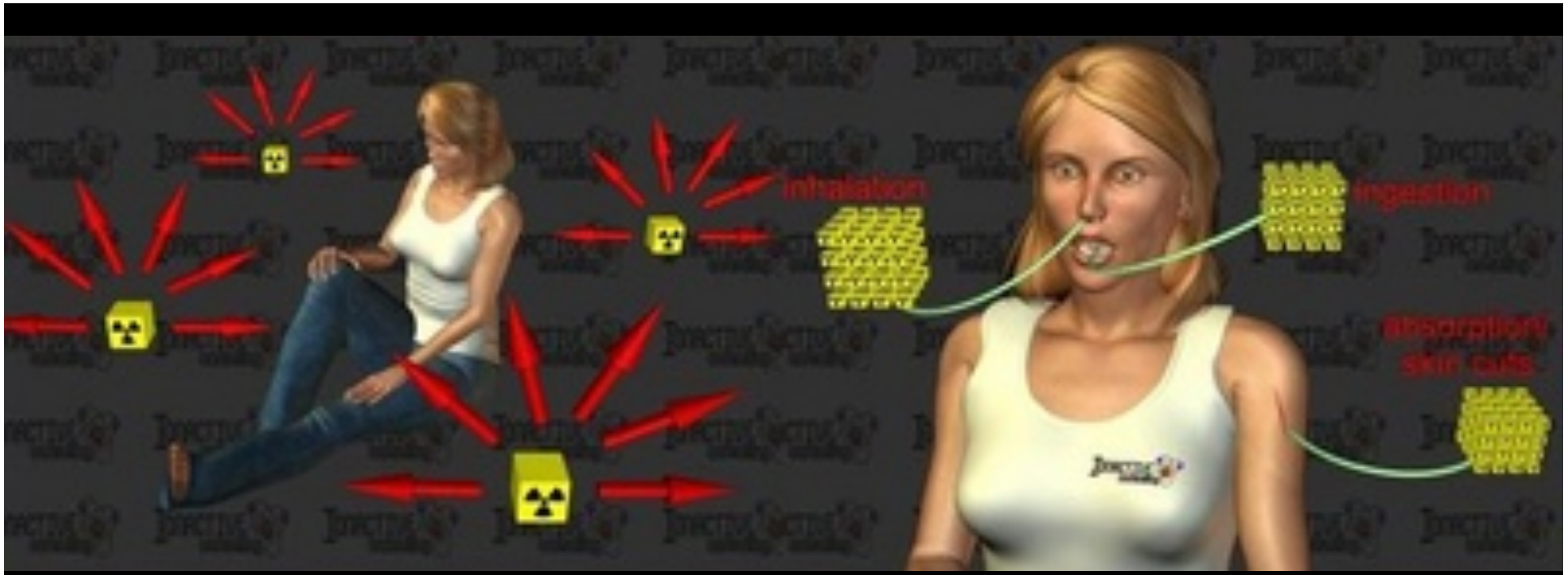
§25.

Increases in the incidence of health effects in populations cannot be attributed to chronic exposure to radiation at levels that are typical of the global average background levels of radiation.

2.Confusion with Quantities and Units


Activity
(Bq)
Fluence
(cm-2)
Absorbed
Dose
(Gy)
WR
Equivalent
Dose (organ)
(Sv)
WT
Efective
Dose
(Sv)

3. Concerns on internal exposure


inhalation
ingestion
absorption
skin cuts

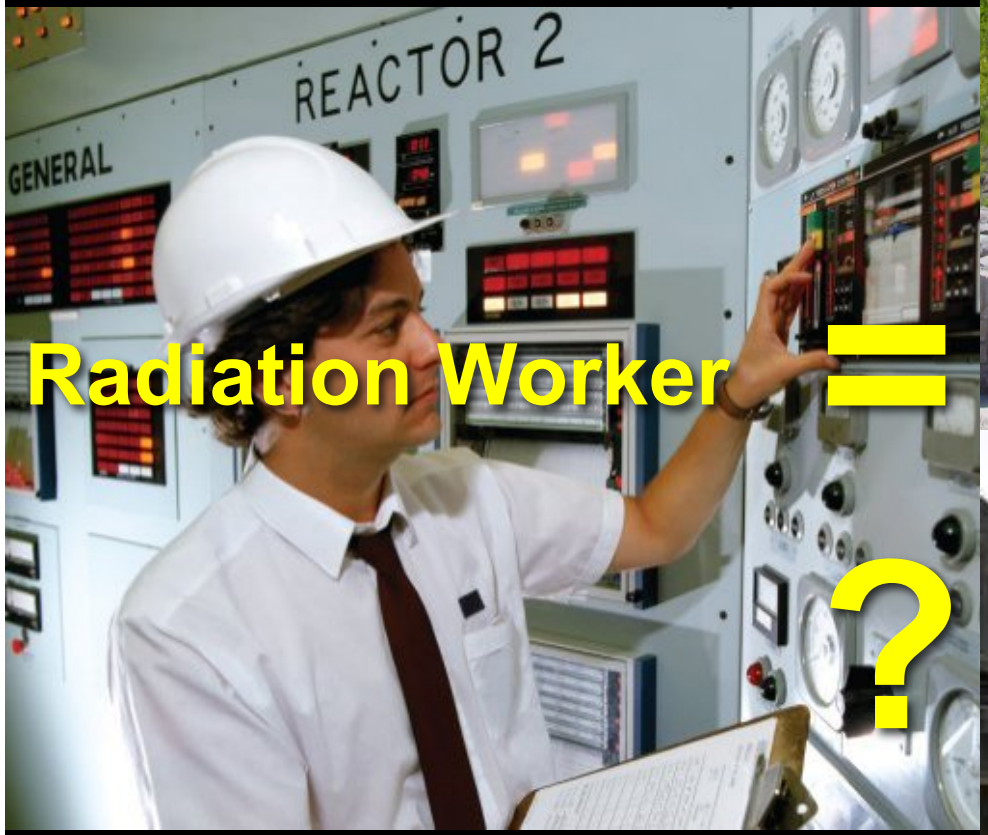
4. Protection of rescuers and volunteers

Radiation Worker

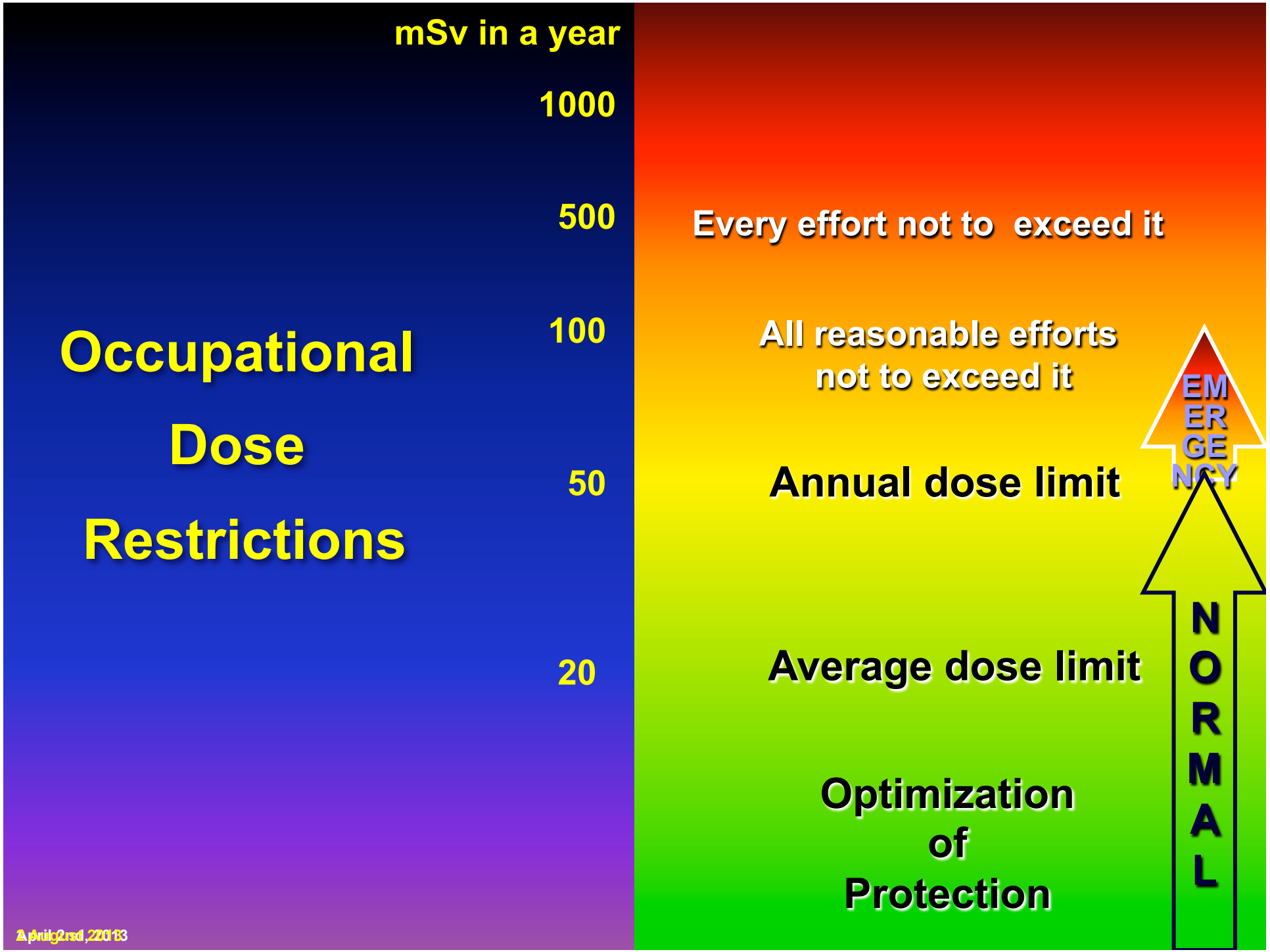
=

?

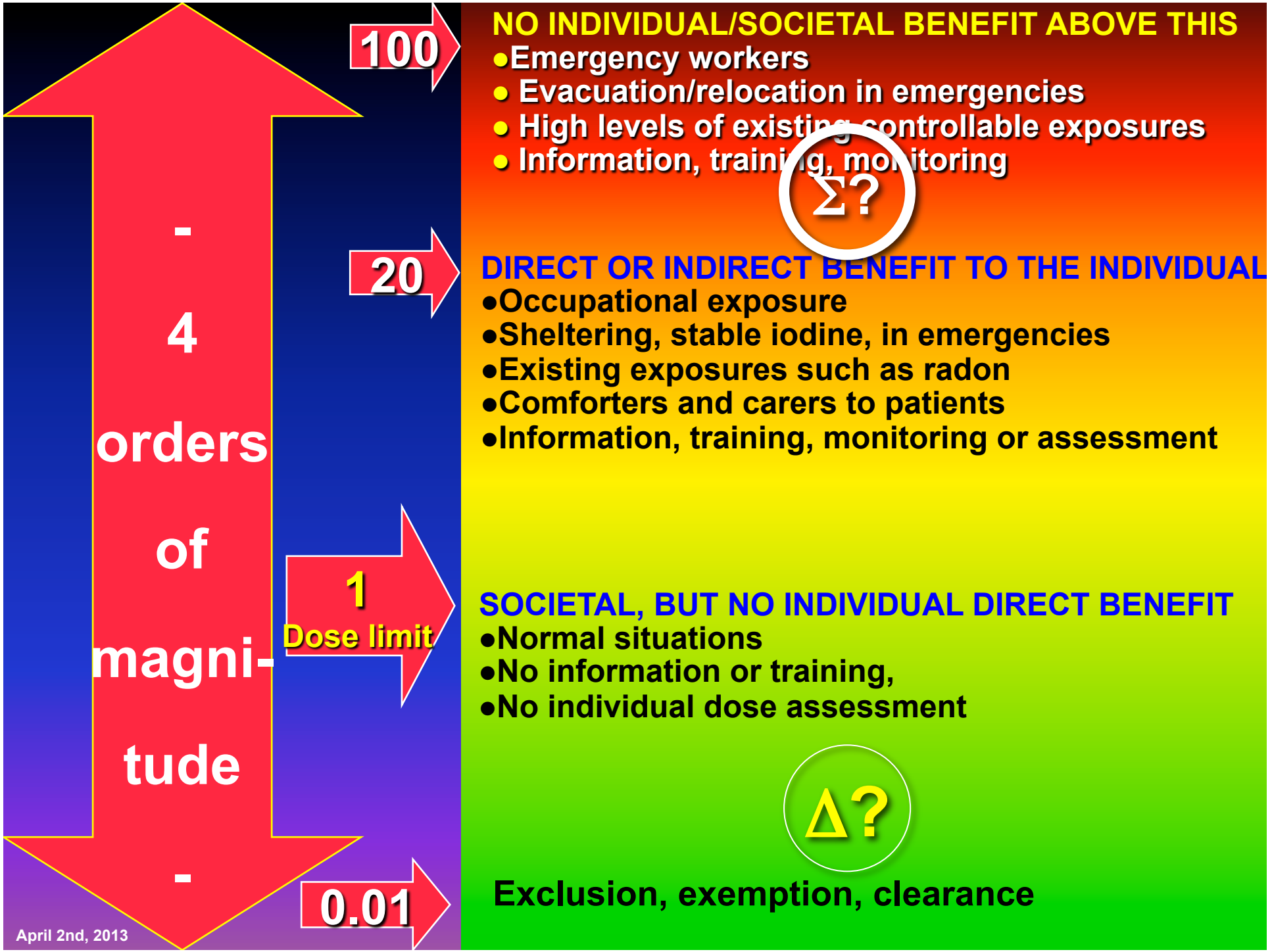
Rescuer



Radiation Worker = Volunteers ?


mSv in a year
1000
500
100
50
20
Occupational
Dose
Restrictions
Every effort not to exceed it
All reasonable efforts
not to exceed it
Annual dose limit
Average dose limit
Optimization
of
Protection
EM
ER
GE
NCY
NORMAL

5. Lessons on Public Protection


100
20
1
Dose limit
0.01
- 4 orders of magni-tude -
NO INDIVIDUAL/SOCIETAL BENEFIT ABOVE THIS
•Emergency workers
• Evacuation/relocation in emergencies
• High levels of existing controllable exposures
• Information, training, monitoring
Σ?
DIRECT OR INDIRECT BENEFIT TO THE INDIVIDUAL
•Occupational exposure
•Sheltering, stable iodine, in emergencies
•Existing exposures such as radon
•Comforters and carers to patients
•Information, training, monitoring or assessment
SOCIETAL, BUT NO INDIVIDUAL DIRECT BENEFIT
•Normal situations
•No information or training,
•No individual dose assessment
Δ?
Exclusion, exemption, clearance
April 2nd, 2013

- A typical question from the public is:

Why doses of 20 to 100 mSv per year are allowed now, after the accident, when doses greater than 1 mSv per year were unacceptable before the accident?

- The Japanese expression for the 1mSv/y dose limit,

線量限度, [線= radiation, 量= amount, 限=border, 度=time]

is unequivocal: amount of radiation dose not to be exceeded in the time.

6. Are Children Properly Protected?

- Parents do not believe that children are adequately protected by the radiation protection standards

The protection of children from the consequences of the accident has been of particular concern in Japan

United Nations
General Assembly

A/AC.82/R.692
Distr.: Restricted

30 April 2012
Original: English only

United Nations Scientific Committee
on the Effects of Atomic Radiation

Fifty-ninth session
Vienna, 21 to 25 May 2012

Agenda item 4(g)
Technical discussions

EFFECTS OF RADIATION EXPOSURE ON CHILDREN

7. Importance of

of clarifying effects on pregnancy

7. Radiation, pregnancy and hereditary effects

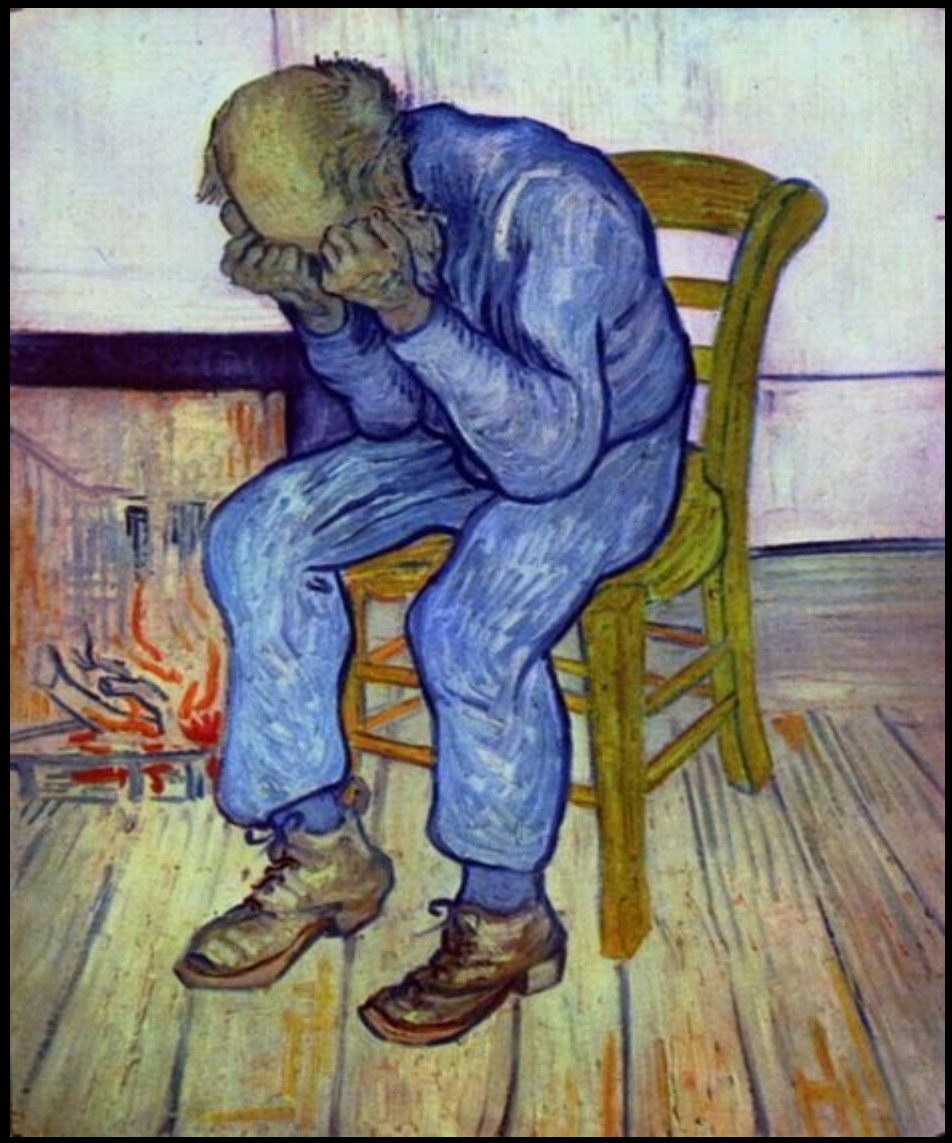
Pregnancy

Should I terminate my pregnancy?

- Stigma is responsible for great apprehension among pregnant women and probably for unnecessary terminations of pregnancies.

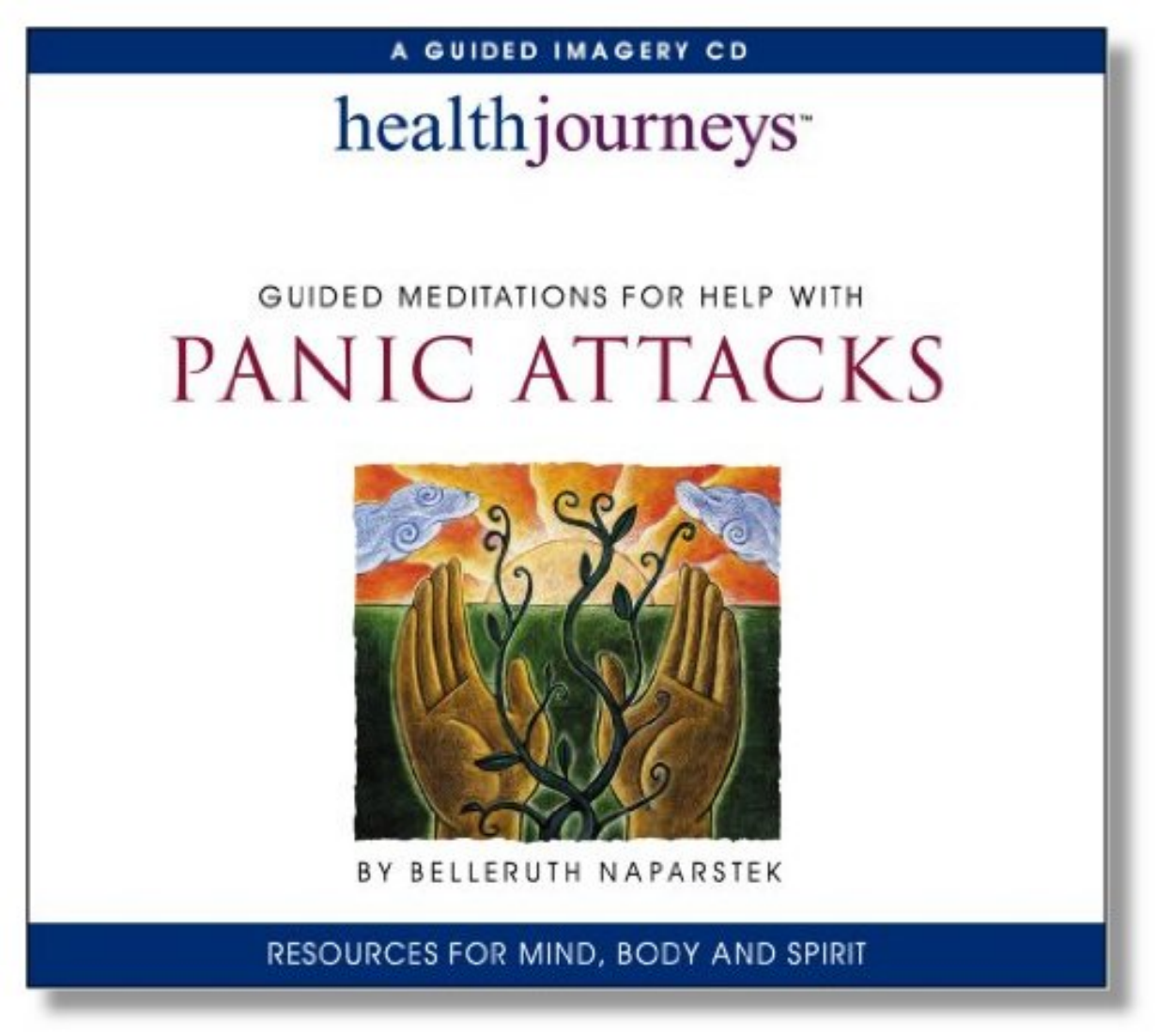
8. The psychological aftermath

Depression

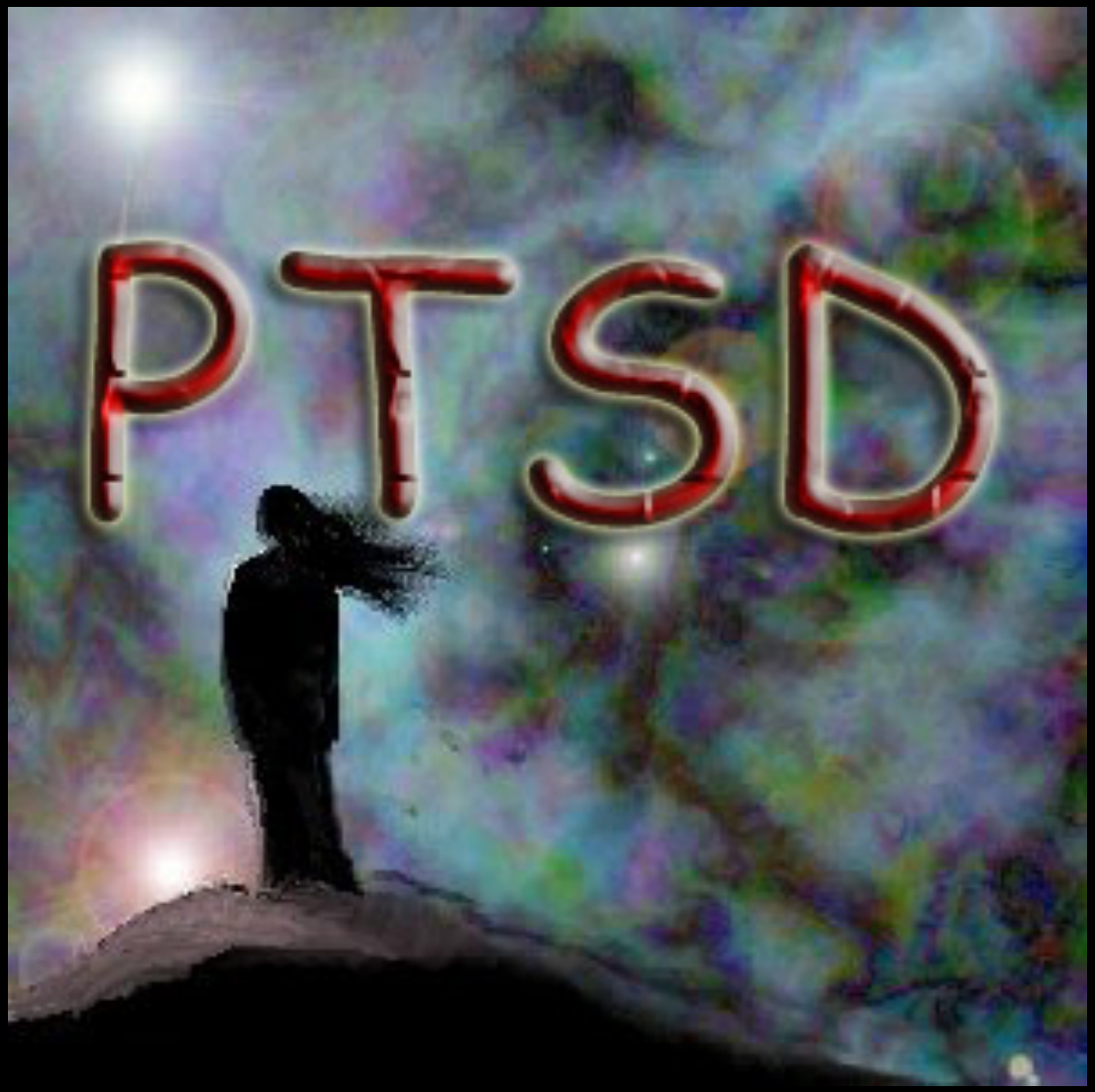


Grieving

Chronic anxiety



Postraumatic Stress Disorder



Insomnia

Severe headaches

Smoking y alcoholism

Anger

Desperation

Paternal Anguish

Stigma

Stigma

Stigma

A mark of disgrace associated with being associated with a radiation- or radioactivity-related accident

- 汚名　：Polluted name
- 烙印　：Mark
- 恥　　：Shame
- 不名誉：Deshonor
- 不面目：Humiliation
- 被差別：Discrimination

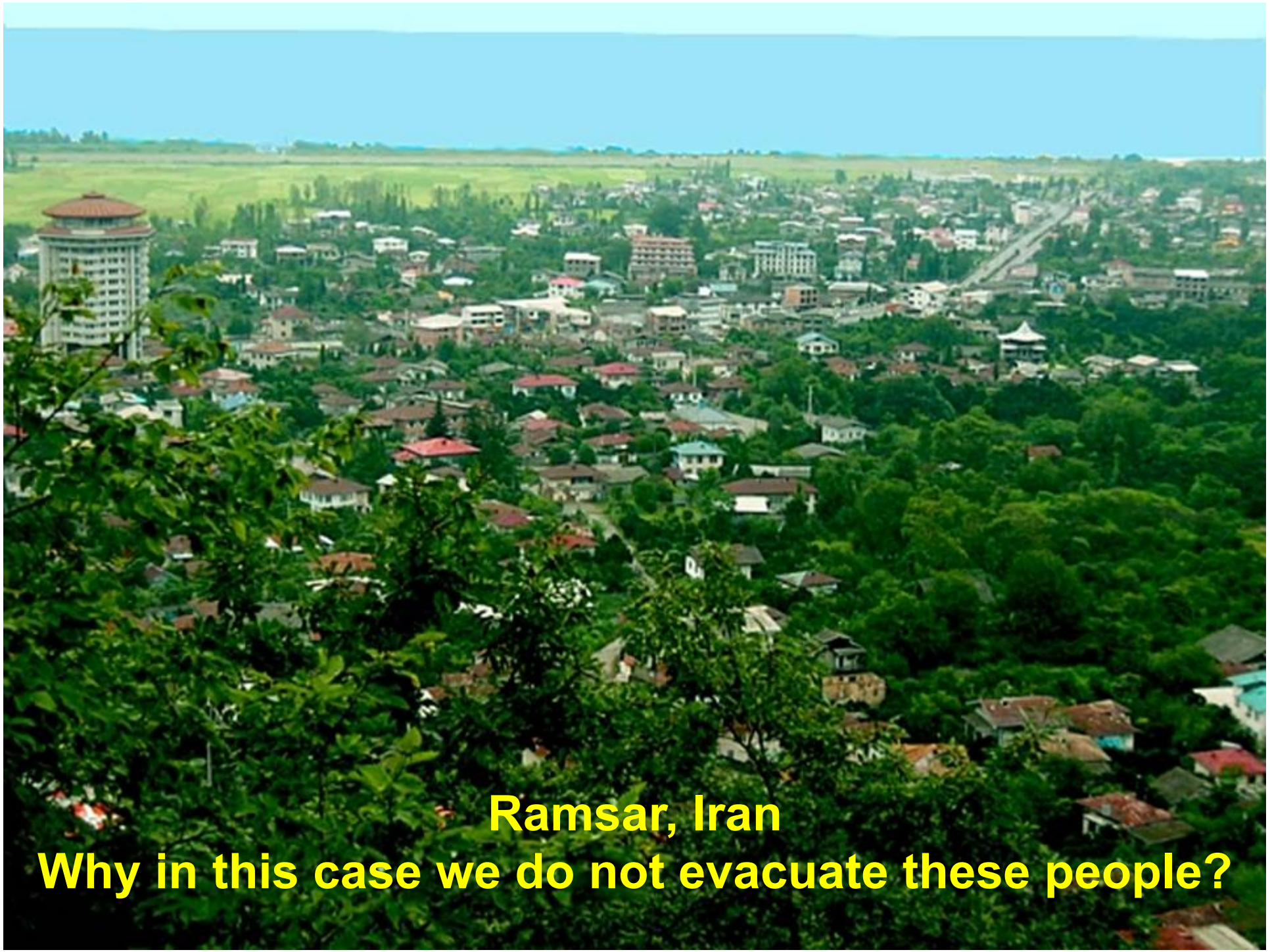
9. Justification

Justification

Good > Bad


Was evacuation justified?

Was good>bad in this case?


Ramsar, Iran
Why in this case we do not evacuate these people?

10. Public Monitoring

Why members of the public are not monitored?

If is it done for them….

….why not for them

11. ‘*Contamination*’

Mission impossible: Dealing with ‘contamination’

‘Contamination' is a confusing term

- from Latin *contaminare*, ‘made impure’.
- Religious origin (e.g., no-kosher food)
- Professional denotation: presence of radioactivity
- Public connotation: radioactive danger

Translation confuses the term even more!
e.g., translation to Japanese

Contamination → 汚染

- 汚 → Dirt, Filth

汚さ → dirtiness　　汚物 → filthiness　　汚泥 → sludge

- 染 → Dyed

汚染 → painted with dirt?

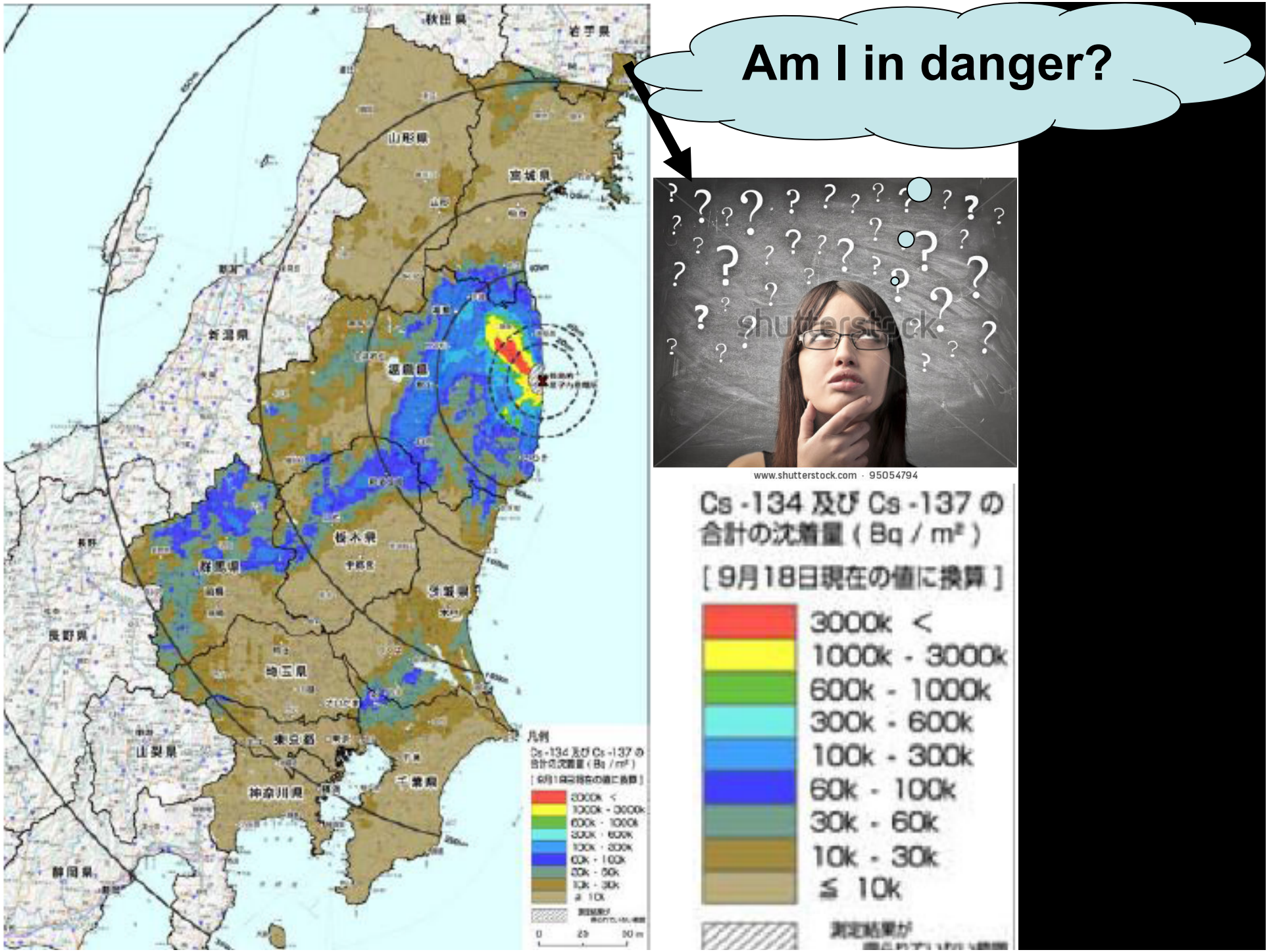

The food is ‘contaminated’, but do not worry the ‘contamination’ is low?

'Contaminated' Territories

What is the meaning of ‘contaminated’ territories?

We are not in danger!

We are in danger!


Am I in danger?
www.shutterstock.com · 95054794
Cs -134 及び Cs -137 の
合計の沈着量 (Bq / m²)
[9月18日現在の値に換算]
3000k <
1000k - 3000k
600k - 1000k
300k - 600k
100k - 300k
60k - 100k
30k - 60k
10k - 30k
≦ 10k
測定結果が
凡例
秋田県
岩手県
山形県
宮城県
新潟県
福島県
栃木県
群馬県
茨城県
長野県
埼玉県
東京都
千葉県
山梨県
神奈川県
静岡県

'Contaminated' Rubble


What are they going to do with all this?

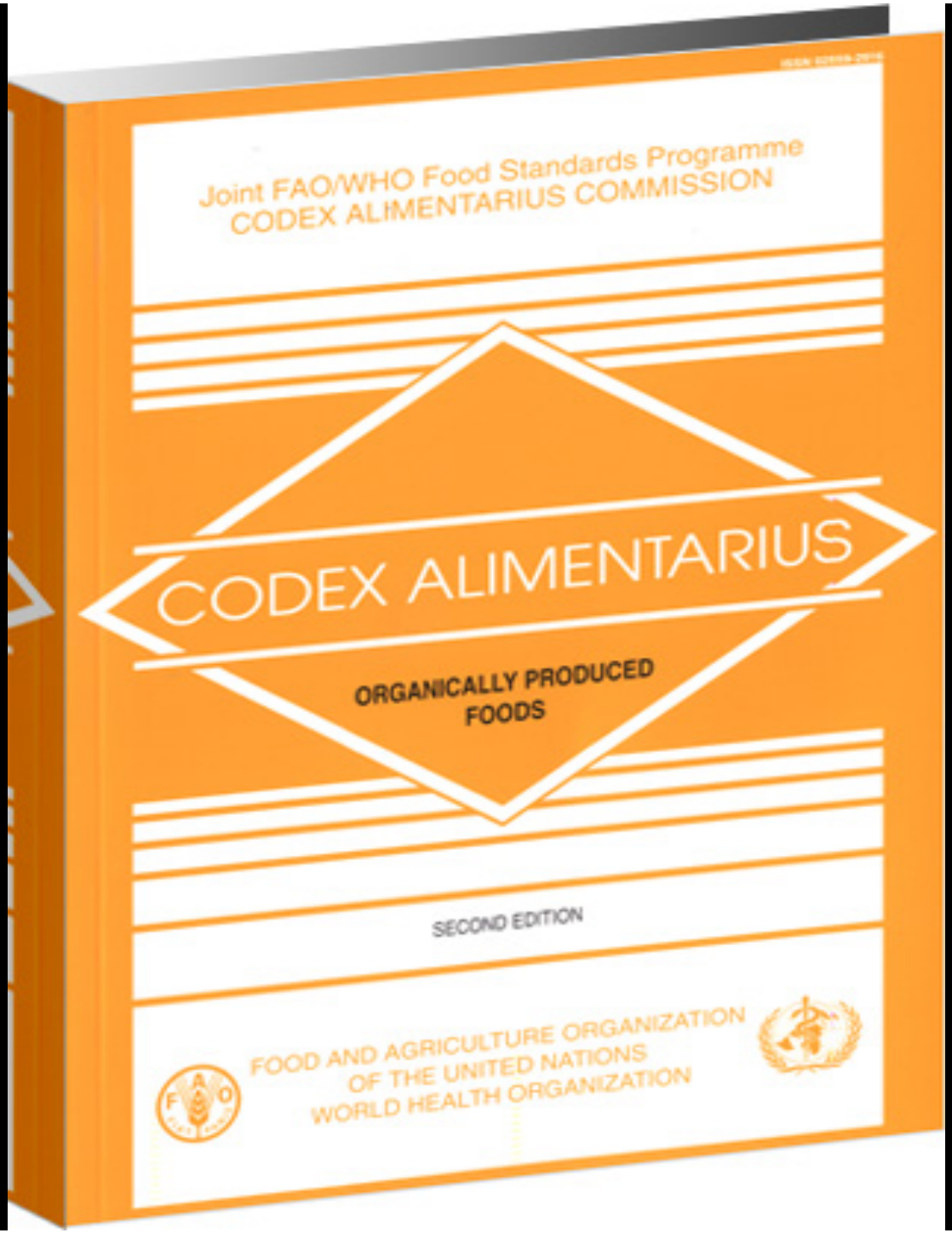
The Radiological Accident in Goiânia

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 1988

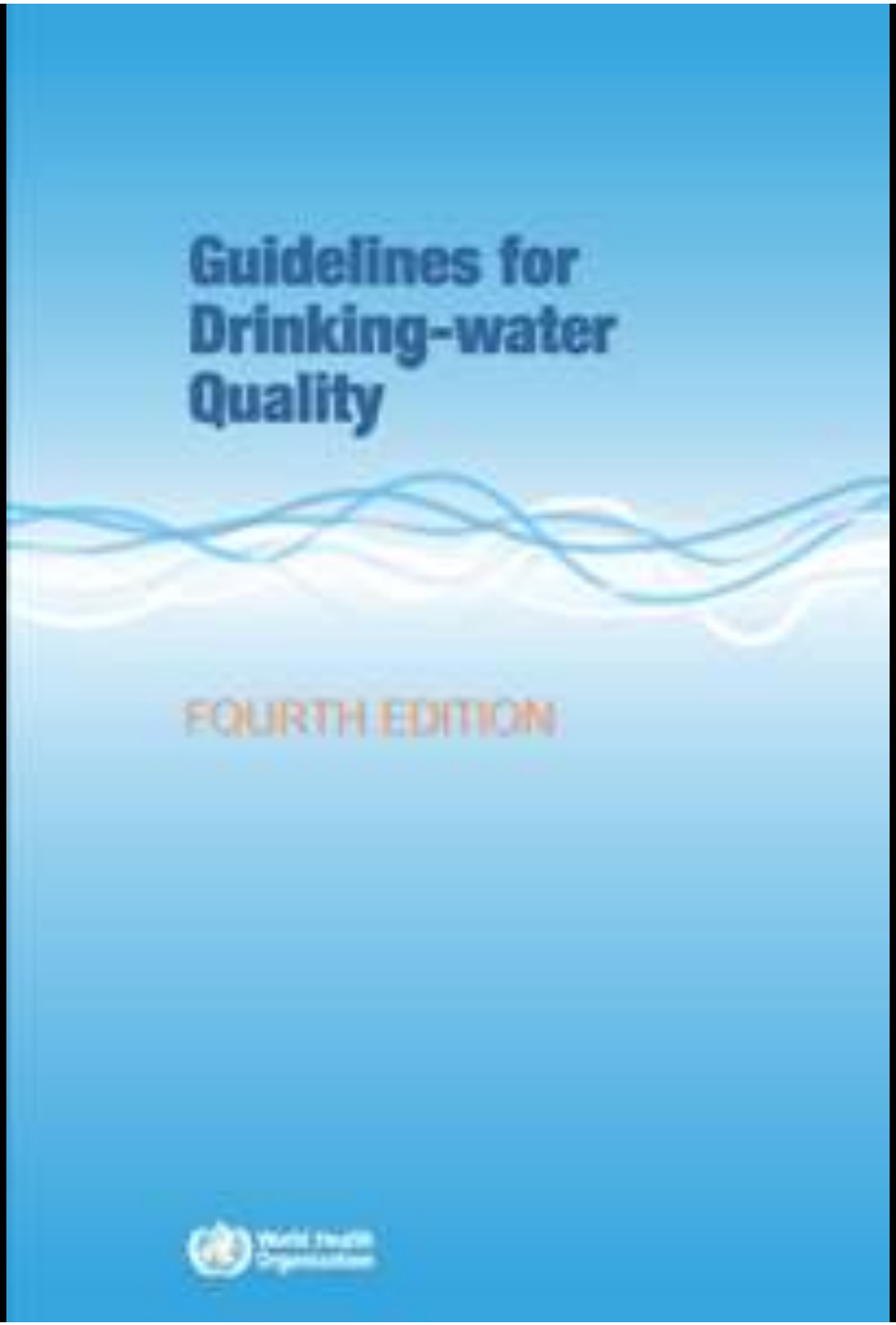
27. Waste containers at the temporary storage site.

'Contaminated' Consumer Products

Foodstuff


Joint FAO/WHO Food Standards Programme
CODEX ALIMENTARIUS COMMISSION
CODEX ALIMENTARIUS
ORGANICALLY PRODUCED FOODS
SECOND EDITION
FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS
WORLD HEALTH ORGANIZATION

Water



Non edible

IAEA SAFETY STANDARDS SERIES

Application of the Concepts of Exclusion, Exemption and Clearance

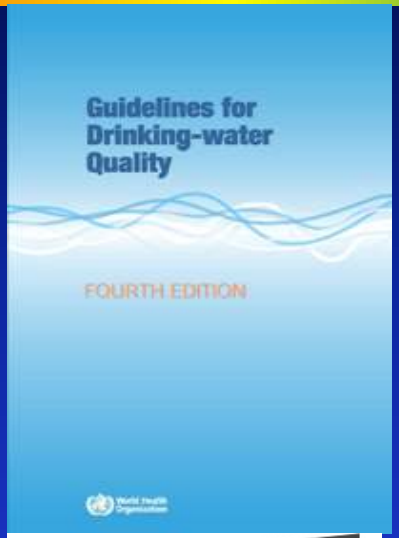
SAFETY GUIDE

No. RS-G-1.7

IAEA
International Atomic Energy Agency

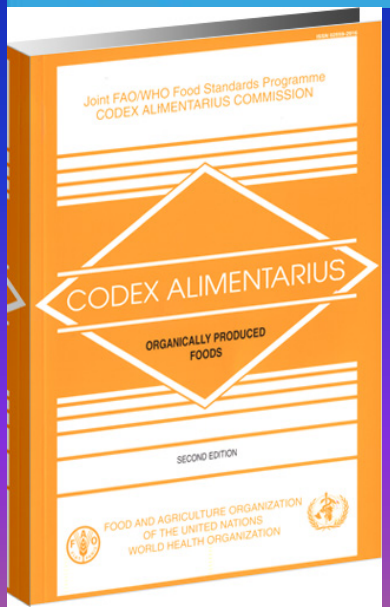
Incoherence in drinking liquids

+



= 10 Bq/l for ^{137}Cs

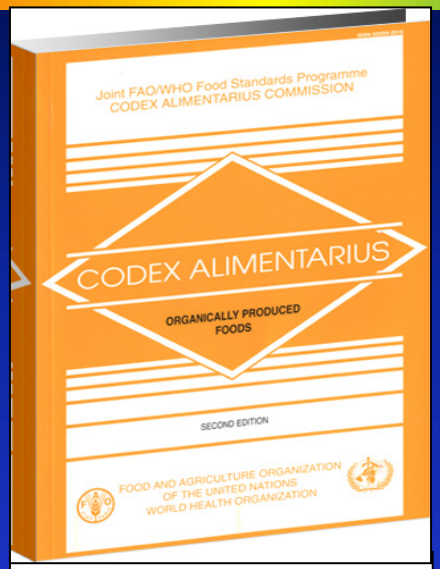
+



= 1000 Bq/l for ^{137}Cs

Incoherence in non-edible vs. edible

+



= 1000 Bq/kg for ^{137}Cs

+

= 100 Bq/kg for ^{137}Cs

New radiation limits in Japan

On April 2012 the Japanese government enforced new limits for cæsium in food:

- Rice, meat, vegetables, fish: 100 Bq/Kg (500 Bq/Kg),
- Milk, milk-powder, infant-food: 50 Bq/Kg (200 Bq/Kg)
- Drinking water: 10 Bq/Kg (200 Bq/Kg)

These kakis (persimmons) contain 90 Bq/kg, but when dried they contain 110;

are they edible?


Why I am permitted to drink this water but not to swim in it?


We were told this water is contaminated;
shall we use it?

Epilogue

- **Many lessons** can be extracted from the international experience on radiological emergencies.

- We have the **ethical duty of learning** from these lessons and feeding-back the results into the international system.

The radiological accidentology is reassuring, because in spite of the amazing scenario of deficiencies, few people have received a lethal dose of radiation!

But reassurance should not be misunderstood as complacency

Reflections

- The nuclear community, namely
  - governmental agencies,
  - regulators and
  - industry,

should learn, understand and apply the concrete lessons derived from radiological emergencies.

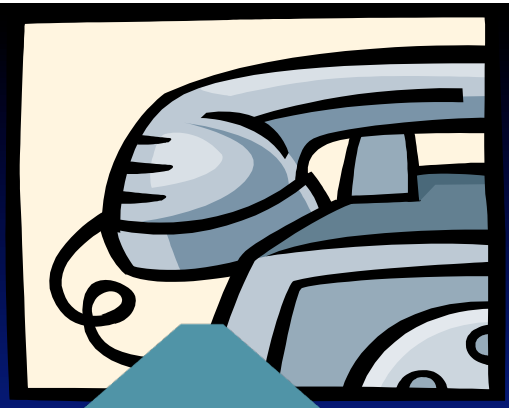
Otherwise:

"Plus ça change, plus c'est pareil

The more it changes, the more it's the same thing"

J.B.A. Karr

Av. del Libertador 8250
Buenos Aires
Argentina



+541163231758

Thank you!

agonzale@arn.gob.ar

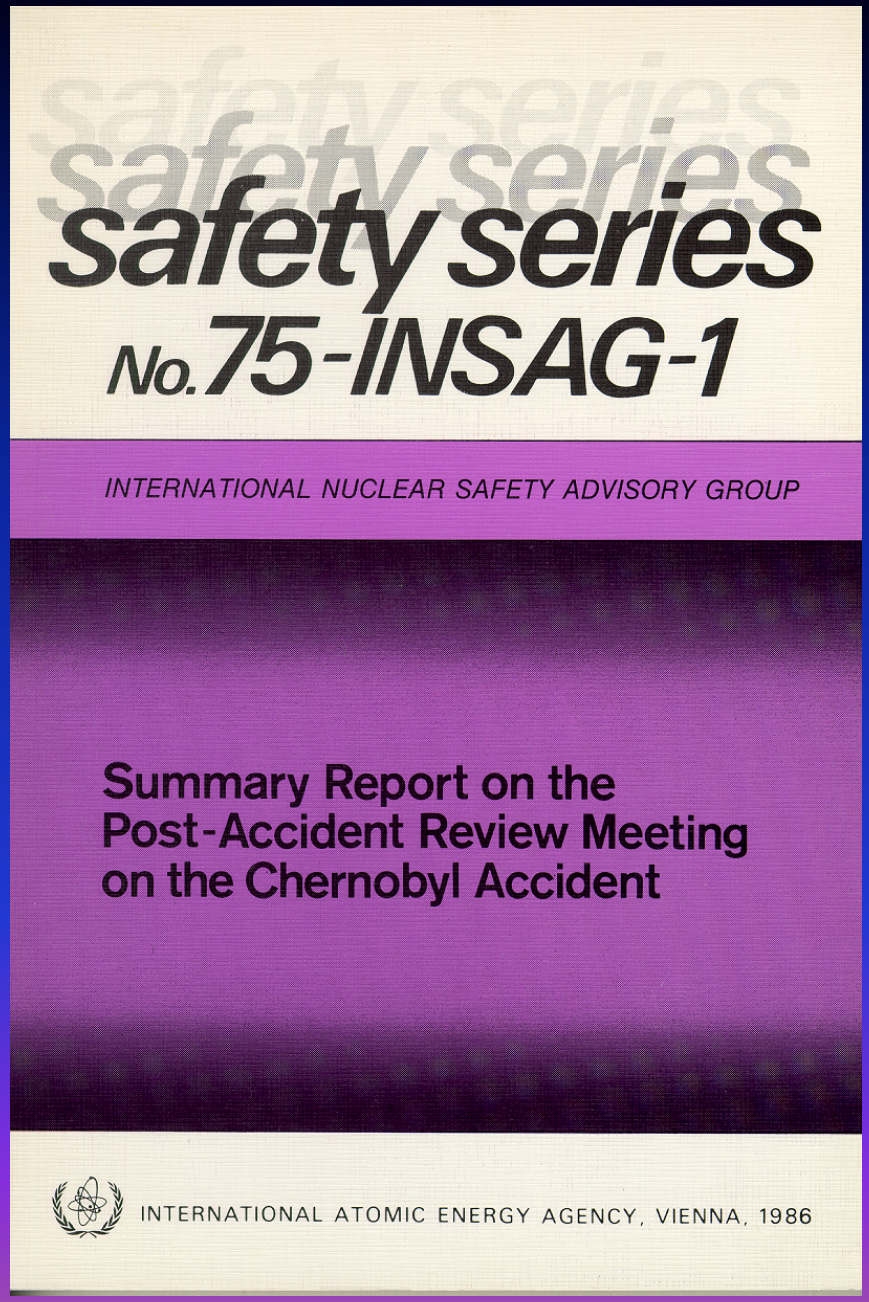
Additional Information

12 lessons learned from Chernobyl

1. Importance of

- sharing information, and
- promptly performing authoritative assessments

- Few weeks after the accident an international evaluation was made.

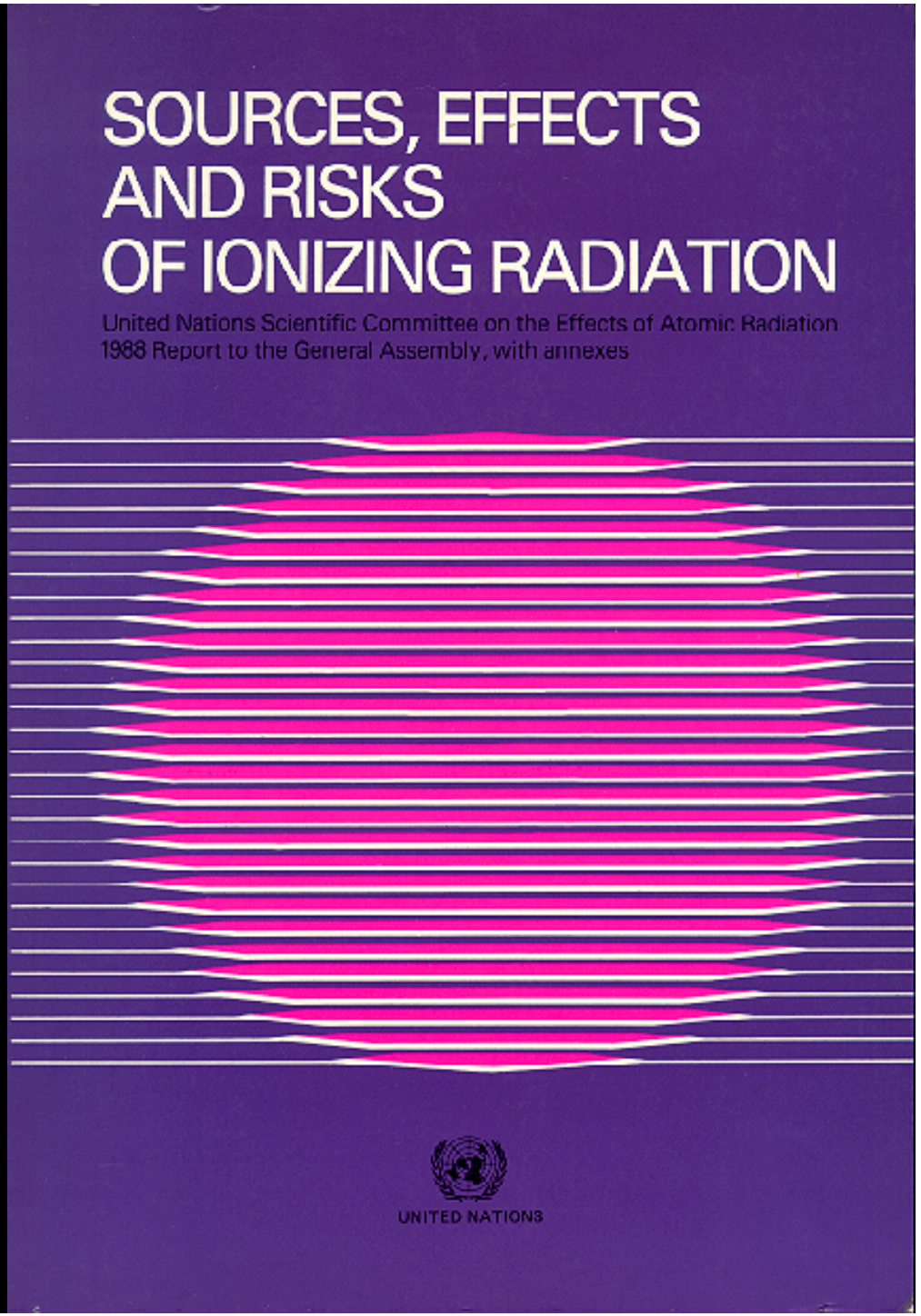


UNSCEAR assessed the

initial radiological

consequences

(published in its 1988 report)



IAEA-TECDOC-516

MEDICAL ASPECTS OF THE CHERNOBYL ACCIDENT

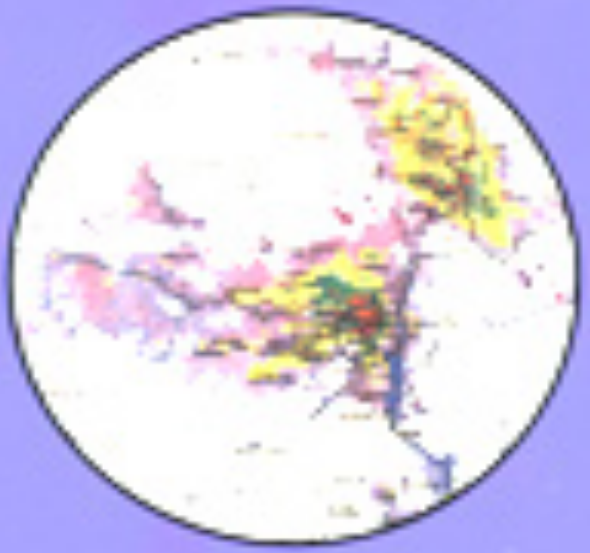
PROCEEDINGS OF AN ALL-UNION CONFERENCE
ORGANIZED BY THE
USSR MINISTRY OF HEALTH
AND THE
ALL-UNION SCIENTIFIC CENTRE OF RADIATION MEDICINE,
USSR ACADEMY OF MEDICAL SCIENCES,
AND HELD IN KIEV, 11–13 MAY 1988

INTERNATIONAL CHERNOBYL PROJECT (1989)

EC
FAO
IAEA
ILO
UNSCEAR
WHO
WMO

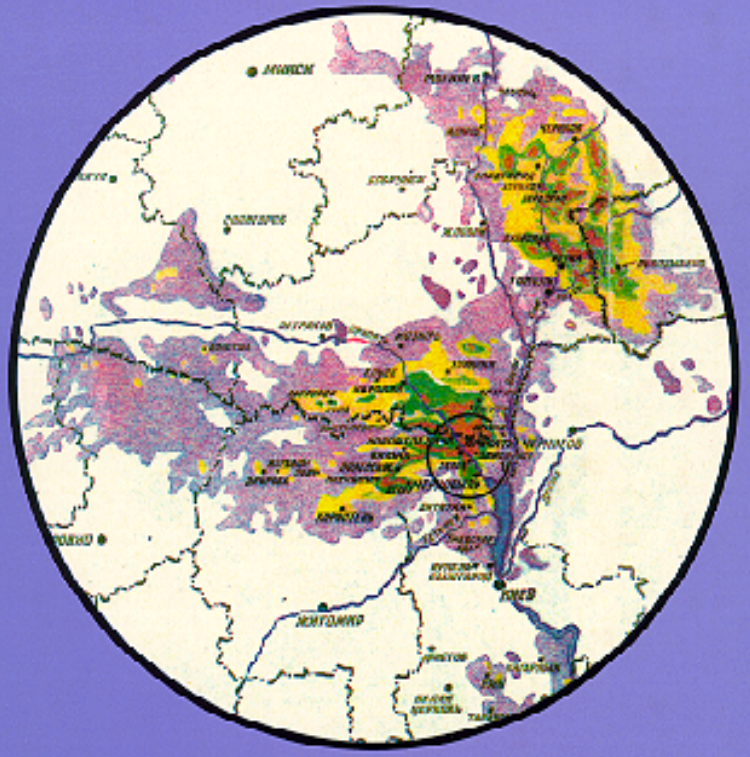
МЕЖДУНАРОДНЫЙ
ЧЕРНОБЫЛЬСКИЙ ПРОЕКТ

ТЕХНИЧЕСКИЙ ДОКЛАД

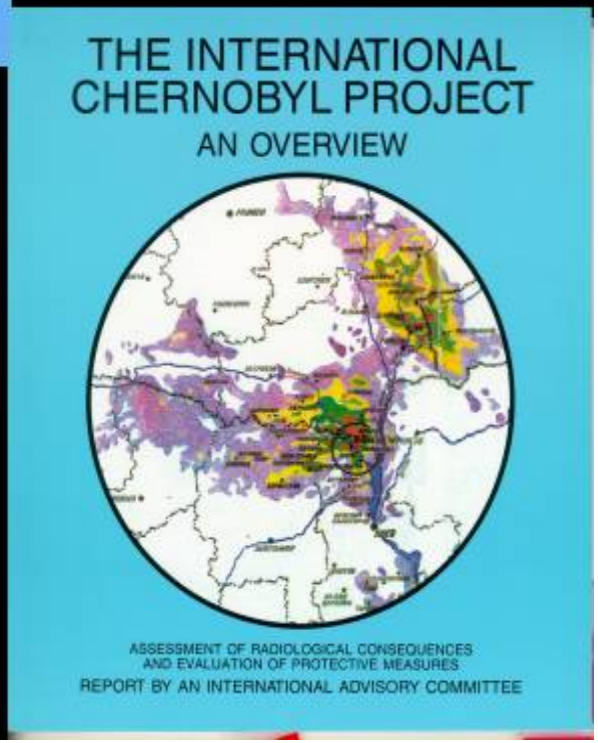


THE INTERNATIONAL CHERNOBYL PROJECT

TECHNICAL REPORT



ASSESSMENT OF RADIOLOGICAL CONSEQUENCES
AND EVALUATION OF PROTECTIVE MEASURES
REPORT BY AN INTERNATIONAL ADVISORY COMMITTEE

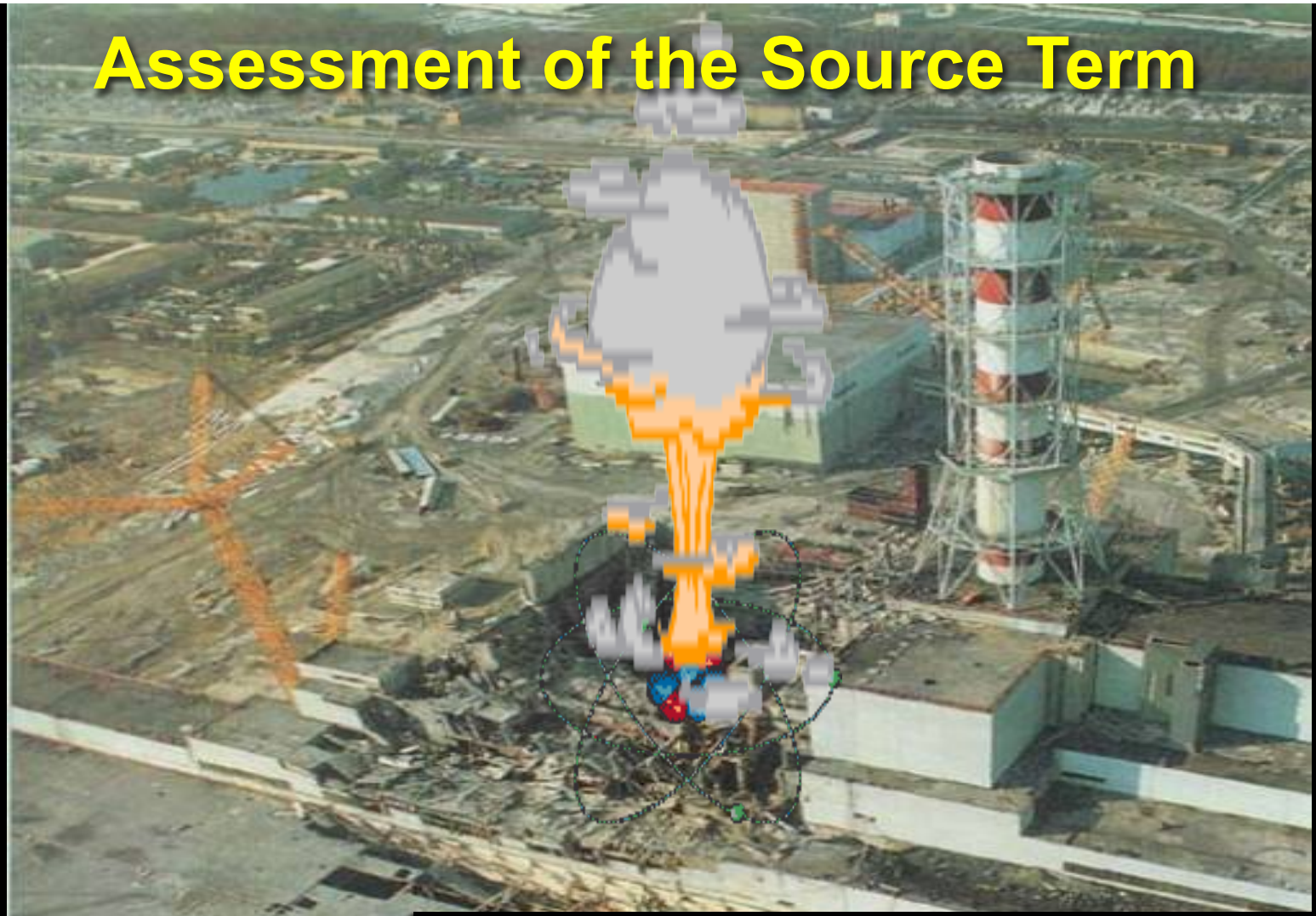


Summary for

decision-makers

2. Importance of promptly assessing the source term

Assessment of the Source Term

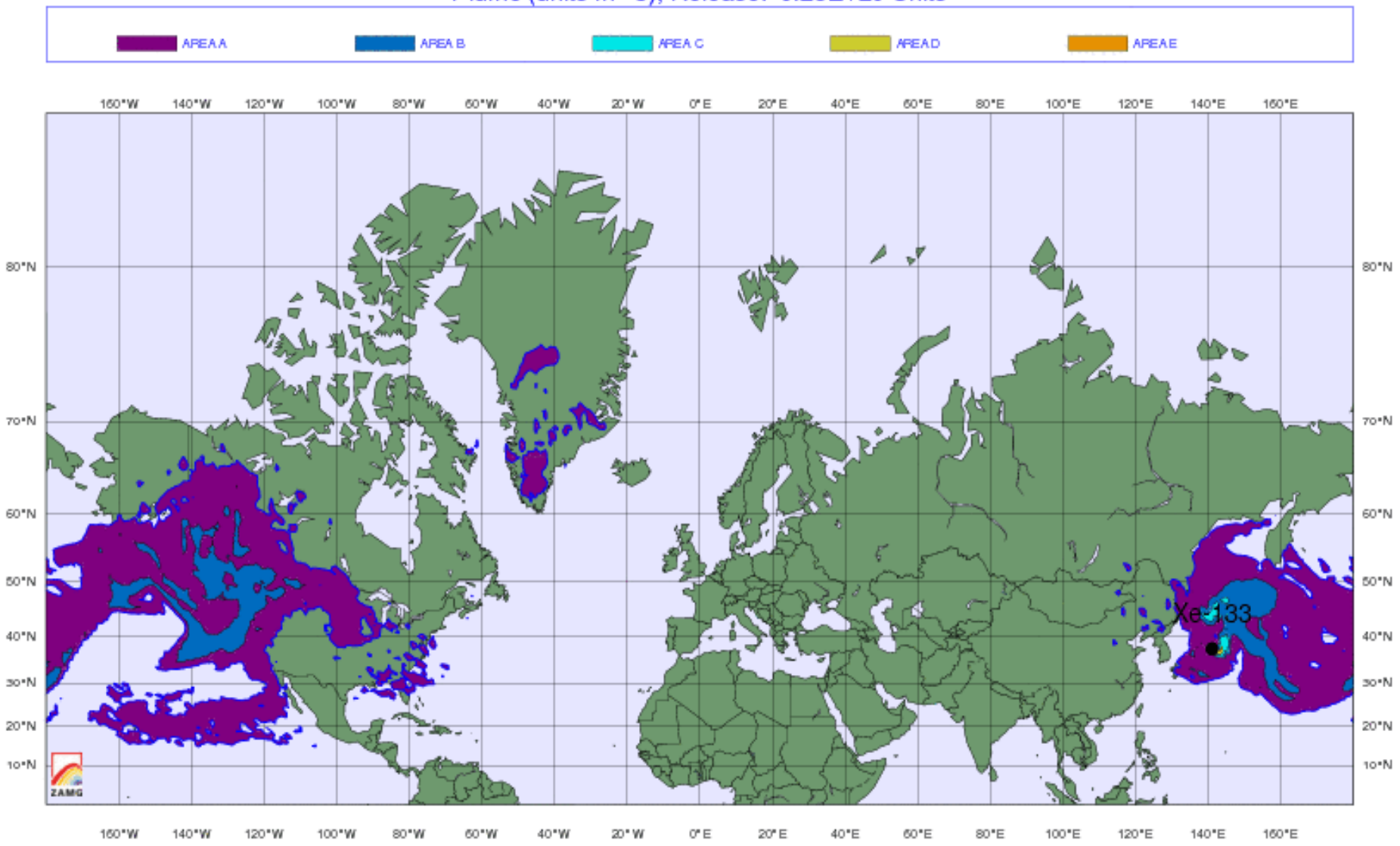


1.2 10^{19} Bq

^{131}I	55%	(50 000 000 Ci)	3,2 10^{18} Bq
^{134,137}Cs	33%		4,0 10^{17} Bq
Noble gases:	100%		7,0 10^{18} Bq

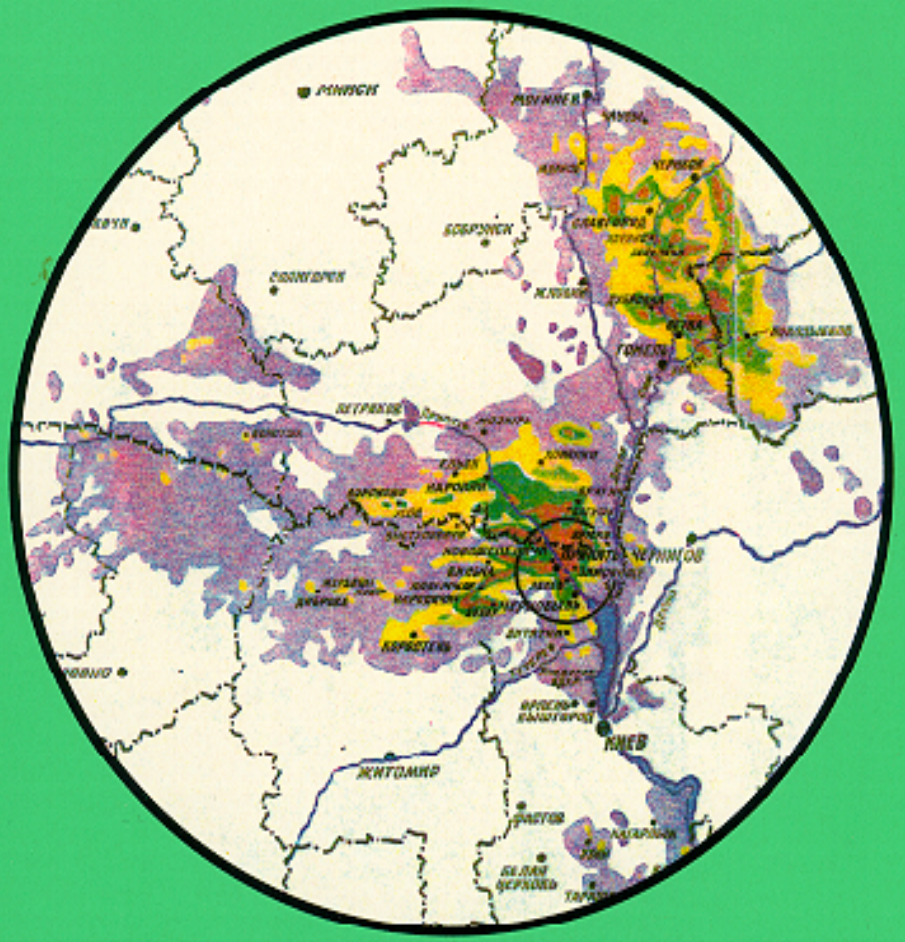
2 August 2013

AKW_FUKUSHIMA-Xe-133
20110508-000000
Plume (units m^-3), Release: 0.25E+20 Units

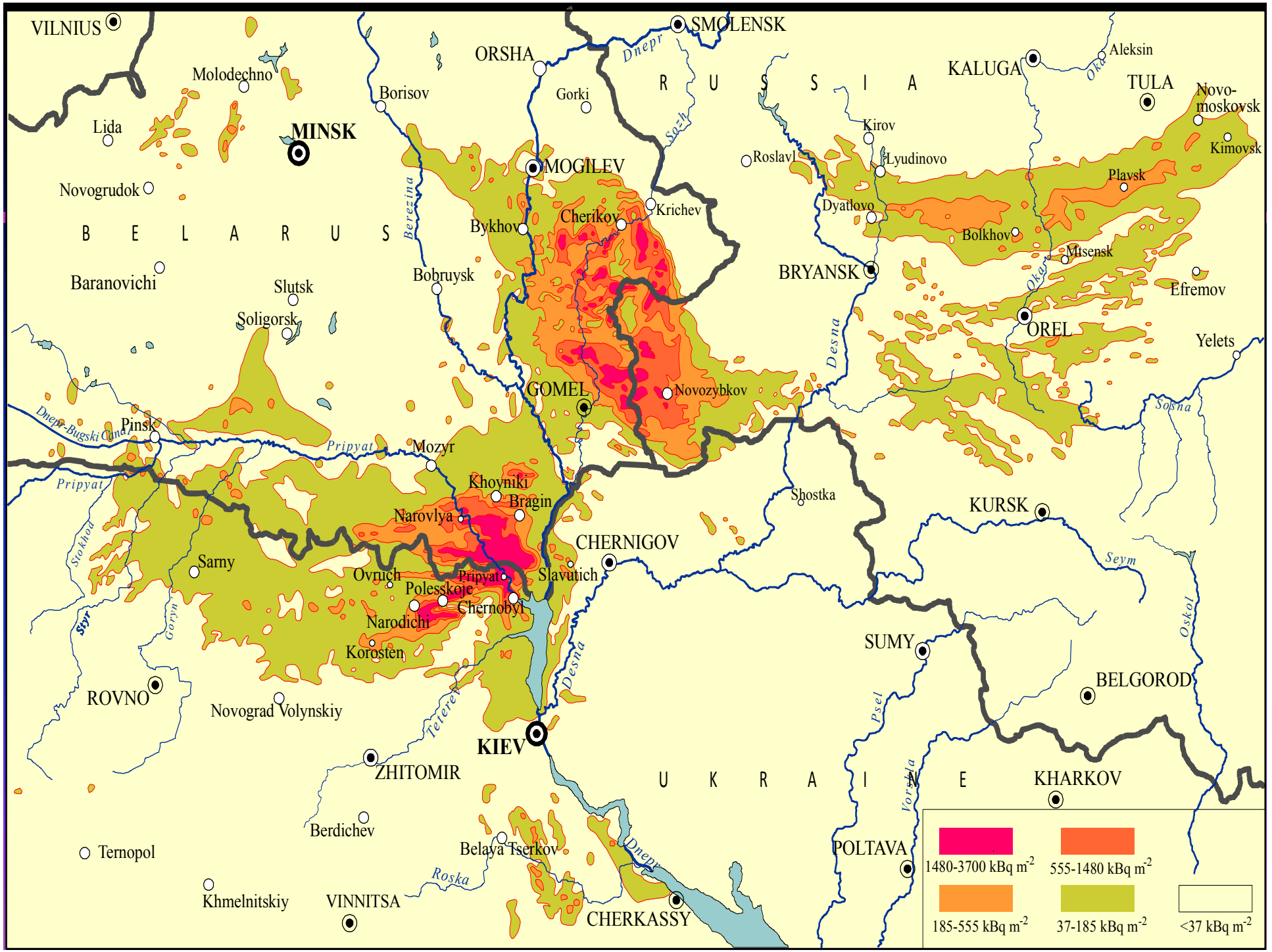


3. Importance of promptly preparing authoritative contamination maps

THE INTERNATIONAL CHERNOBYL PROJECT

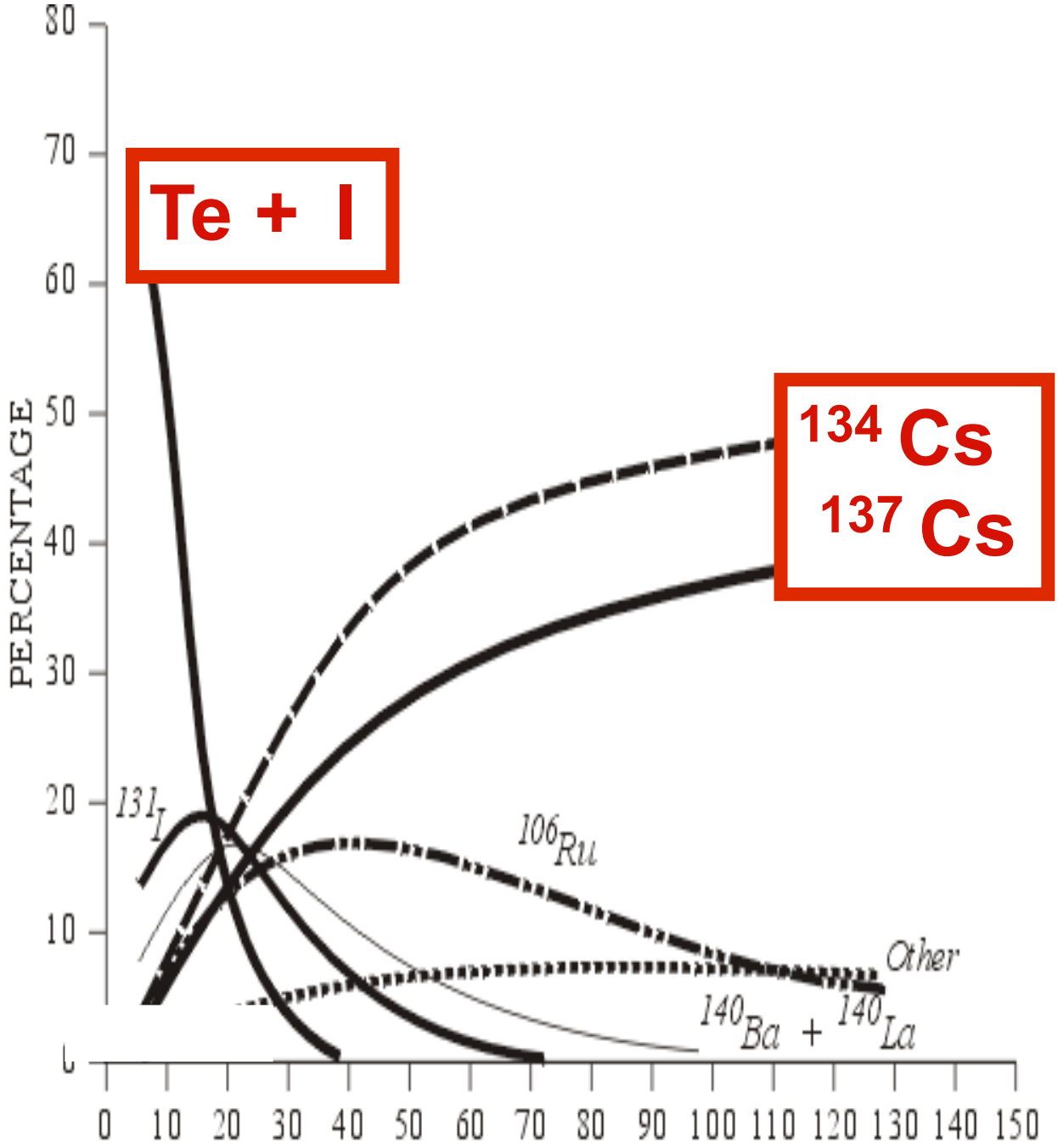


SURFACE CONTAMINATION MAPS


VILNIUS
Molodechno
Lida
MINSK
Novogrudok
Baranovichi
Slutsk
Soligorsk
Pinsk
Dnepr-Bugski Kanal
Pripyat
Stokhod
Styr
Goryn
Sarny
ROVNO
Novograd Volynskiy
Ternopol
Khmelnitskiy
VINNITSA
Berdichev
ZHITOMIR
KIEV
Tetерev
Roska
Belaya Tserkov
Dnepr
CHERKASSY
Ovruch
Polesskoje
Pripyat
Chernobyl
Narodichi
Korosten
Mozyr
Khoyniki
Bragin
Narovlya
GOMEL
Novozybkov
Bobruysk
Bykhov
Cherikov
Krichev
MOGILEV
Berezina
Borisov
ORSHA
Gorki
SMOLENSK
Dnepr
Sozh
Roslavl
Kirov
Lyudinovo
Dyatlovo
Bolkhov
Mtsensk
BRYANSK
Desna
Oka
OREL
Efremov
Yelets
Sosna
Shostka
KURSK
Seym
Oskol
CHERNIGOV
Slavutich
SUMY
Psel
Vorskla
BELGOROD
KHARKOV
POLTAVA
KALUGA
Aleksin
TULA
Novo-moskovsk
Kimovsk
Plavsk
B E L A R U S
R U S S I A
U K R A I N E
1480-3700 kBq m-2
555-1480 kBq m-2
185-555 kBq m-2
37-185 kBq m-2
<37 kBq m-2

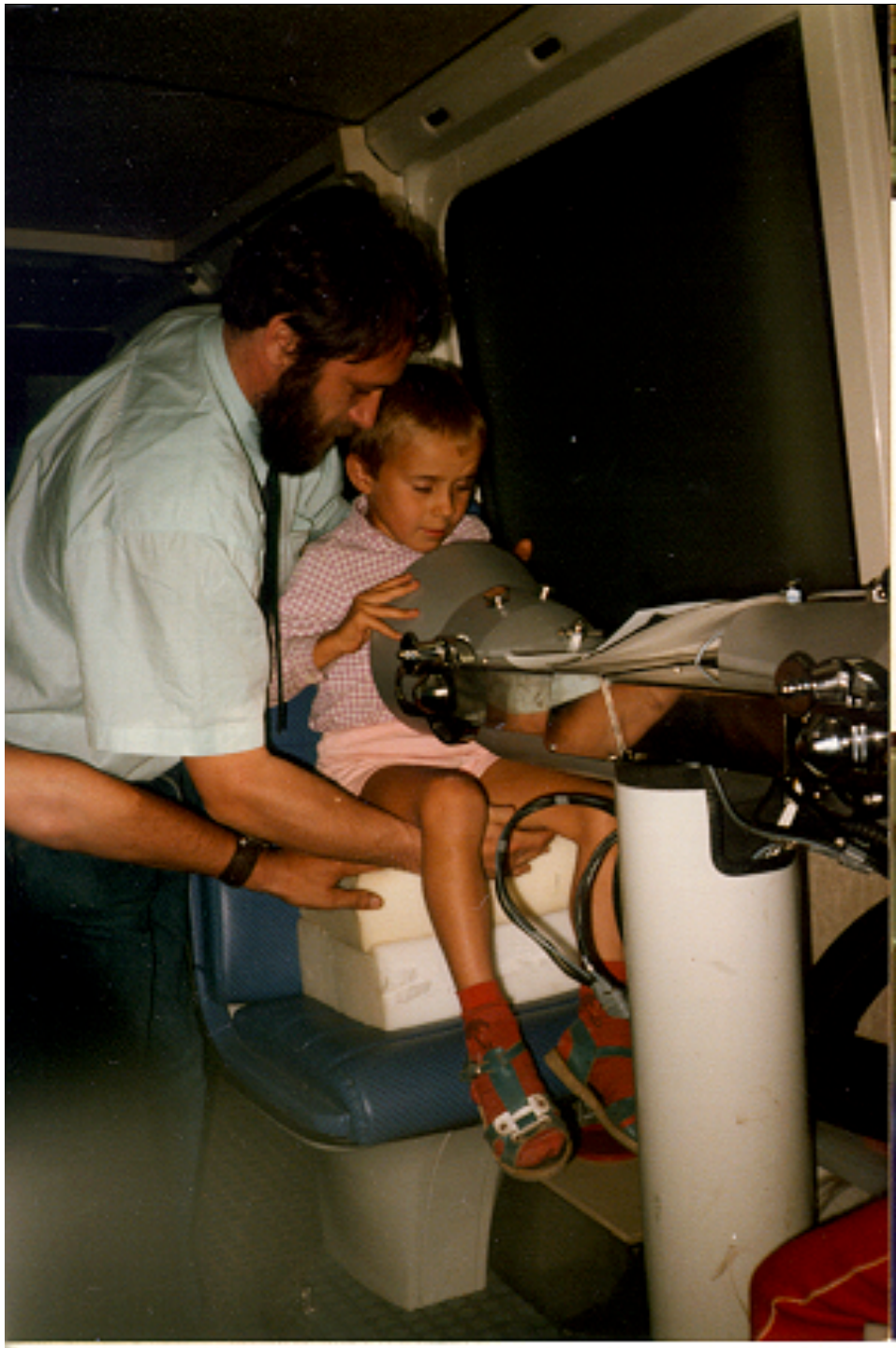
4. Importance of promptly performing individual monitoring

Relevant nuclides: Contribution to doses



April 2nd, 2013

In Chernobyl, more than 16,000 inhabitants were monitored *In Situ*

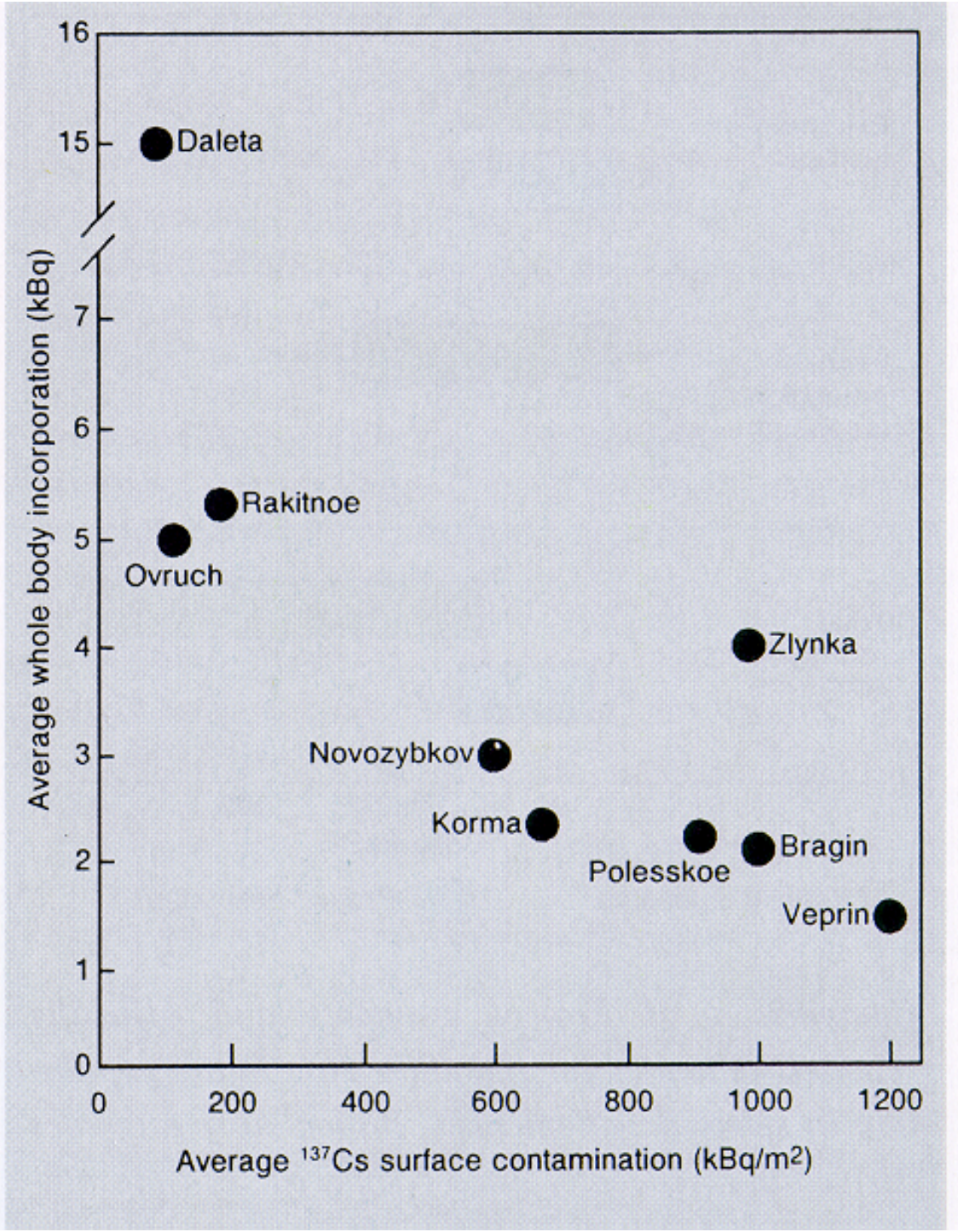


High contamination

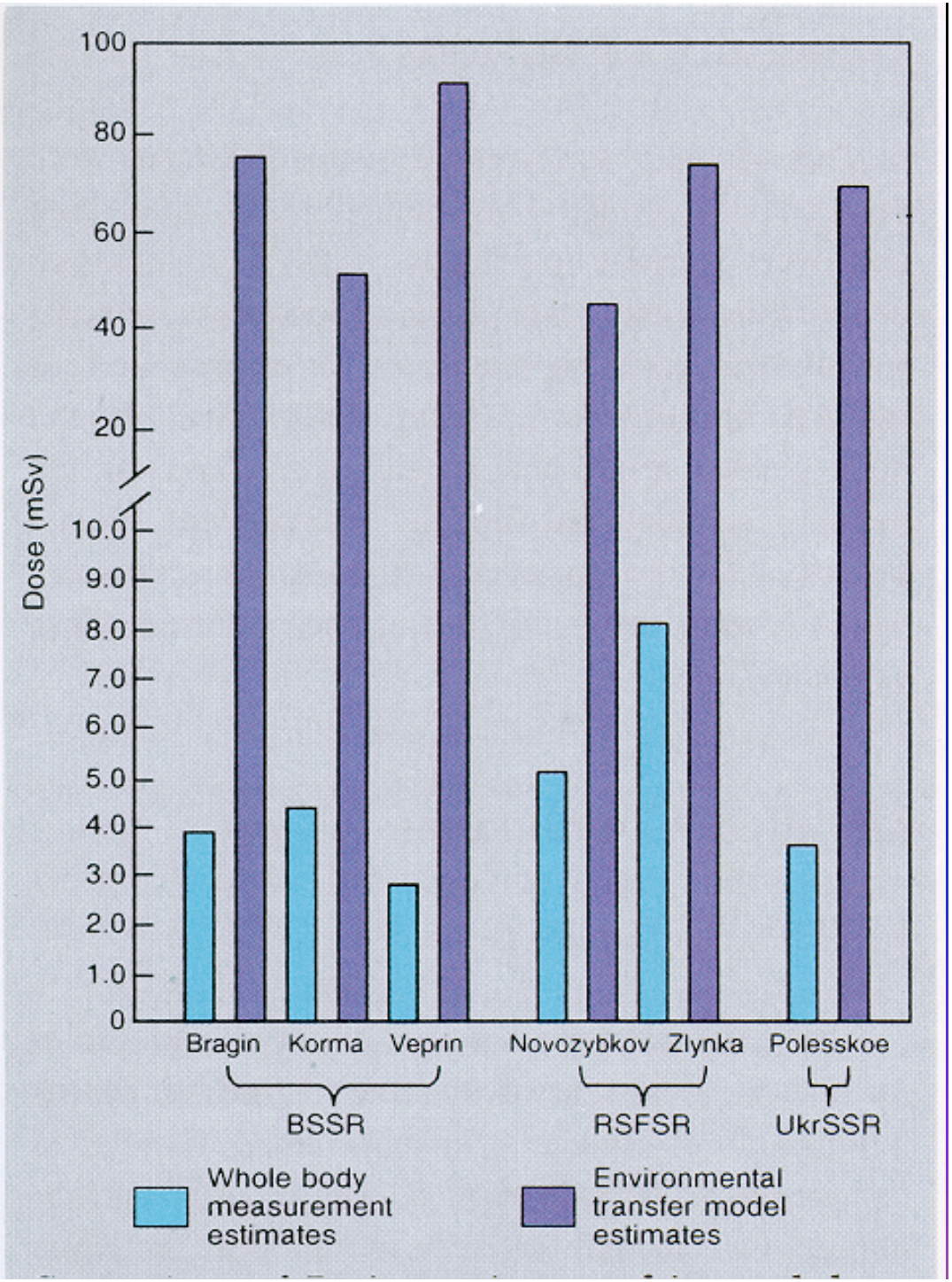
≠

High dose

Higher contamination does not necessarily deliver higher doses!



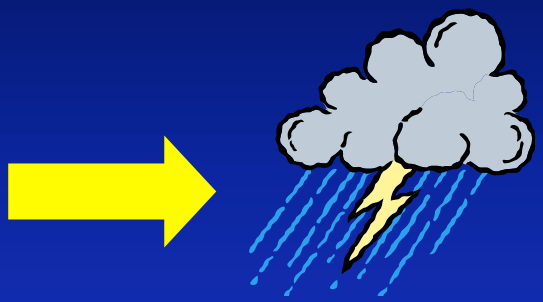
Radiation doses measured *in vivo* were much lower than those estimated **theoretically**.

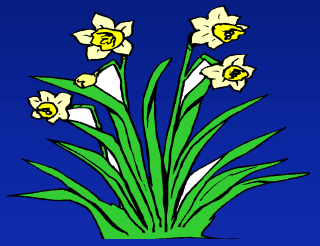


5. Importance of protecting children against radio-iodine intake

Chernobyl drama: thyroid

Pasture-cow-milk pathway (^{131}I)





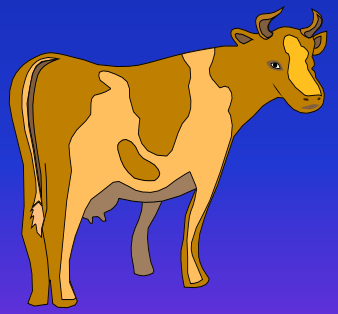
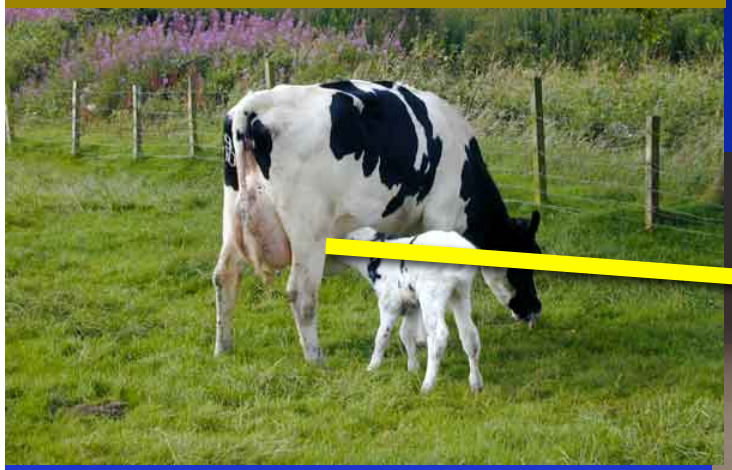
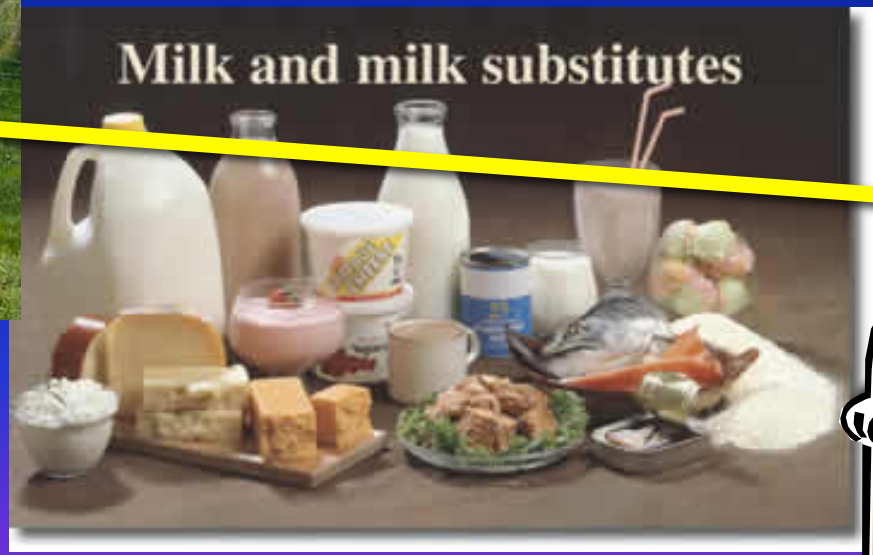


Figure 29-9. Fallout.



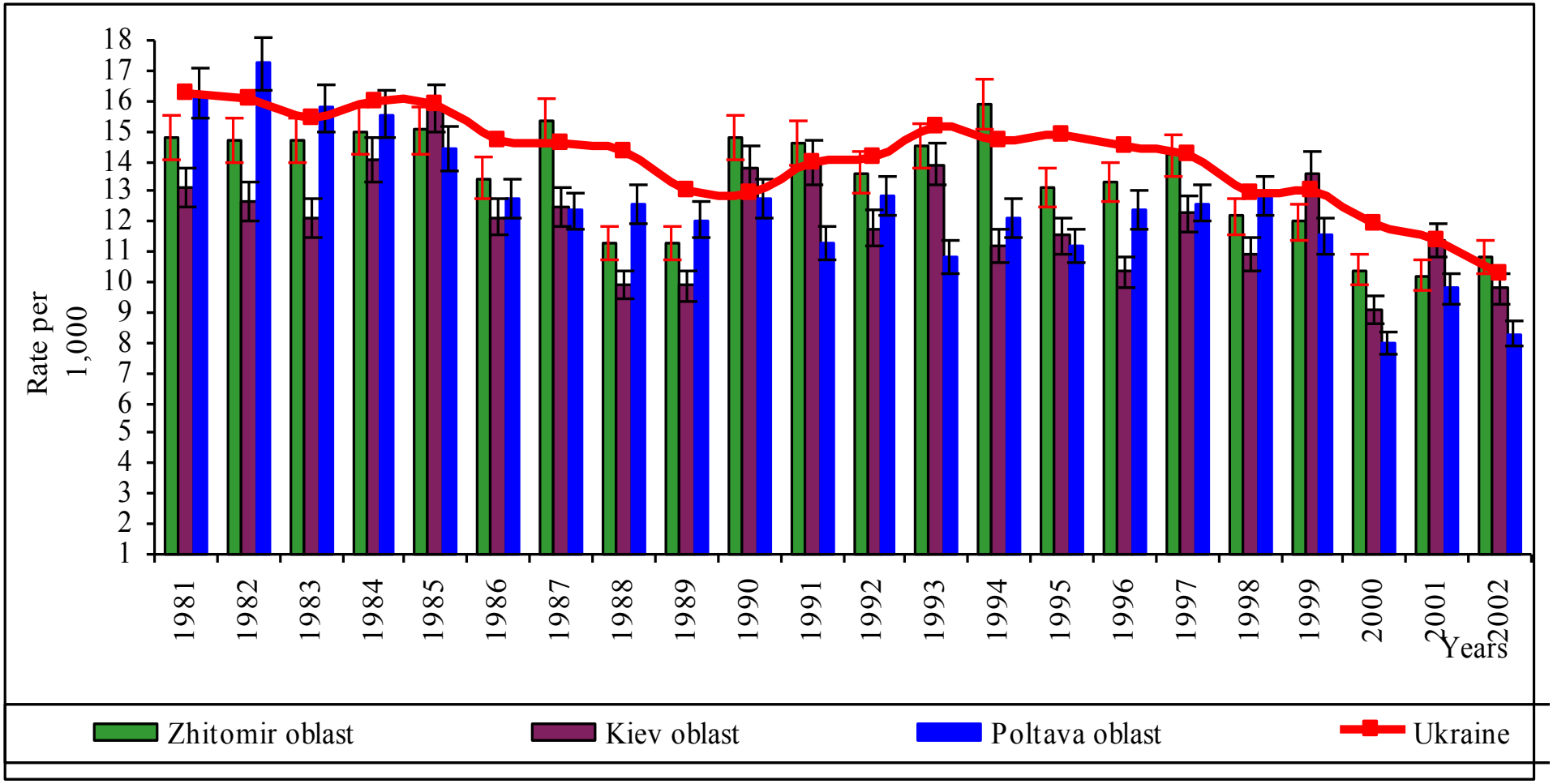


6. Importance of

of clarifying effects on pregnancy

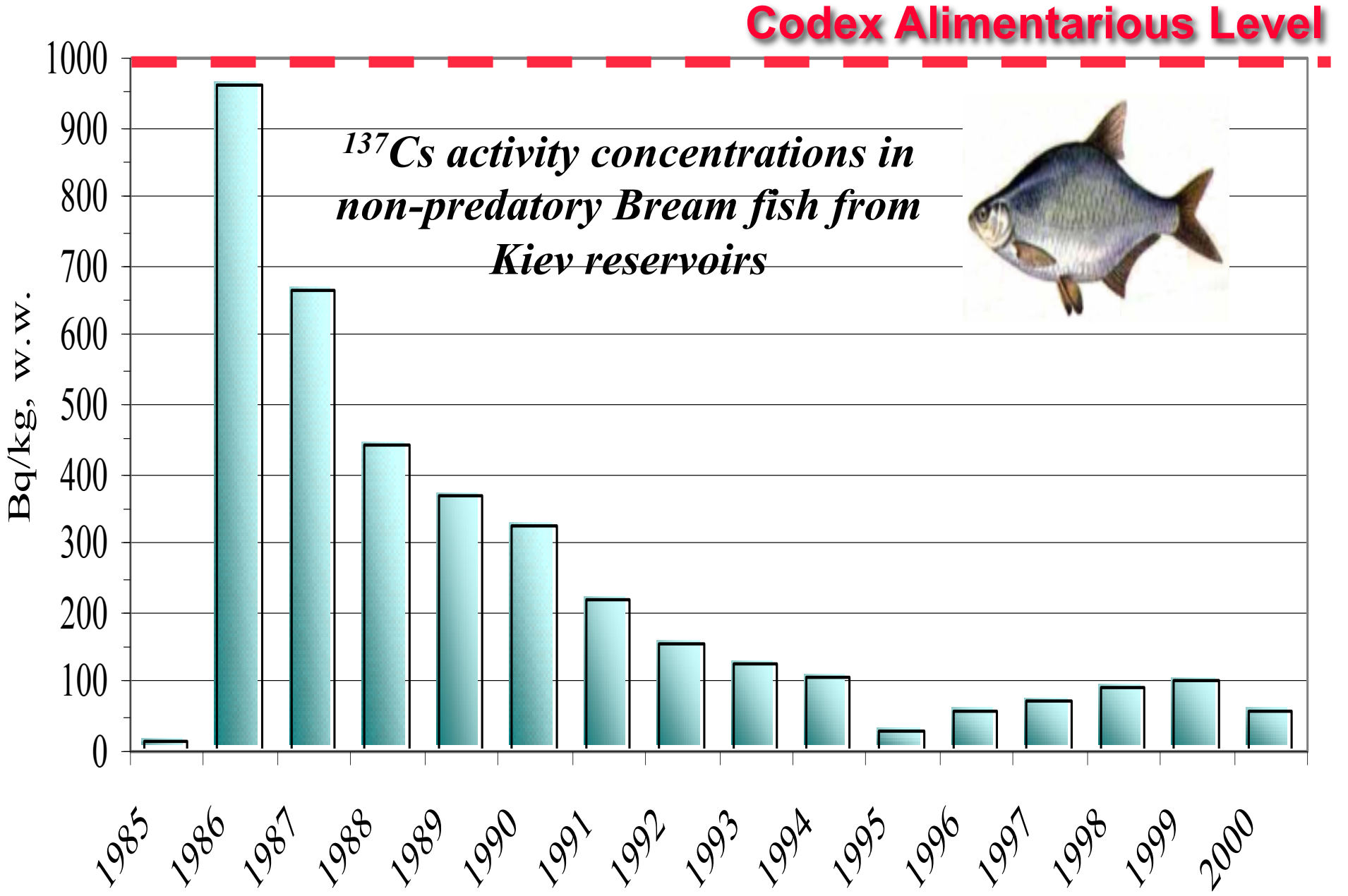
Radiation, pregnancy and hereditary effects

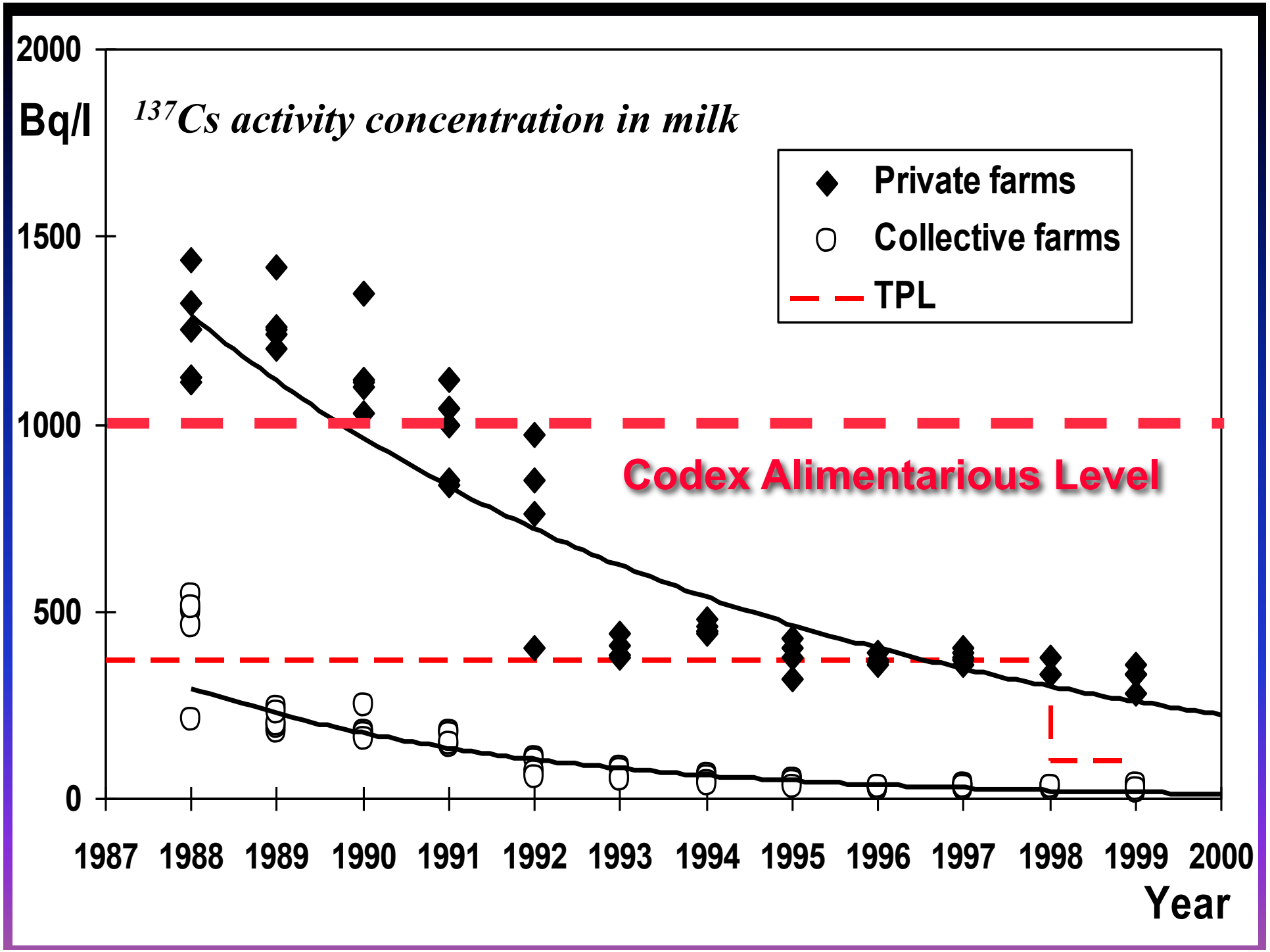
Infant mortality in the contaminated regions around Chernobyl was not increased



Contaminated oblasts vs Ukraine as a whole

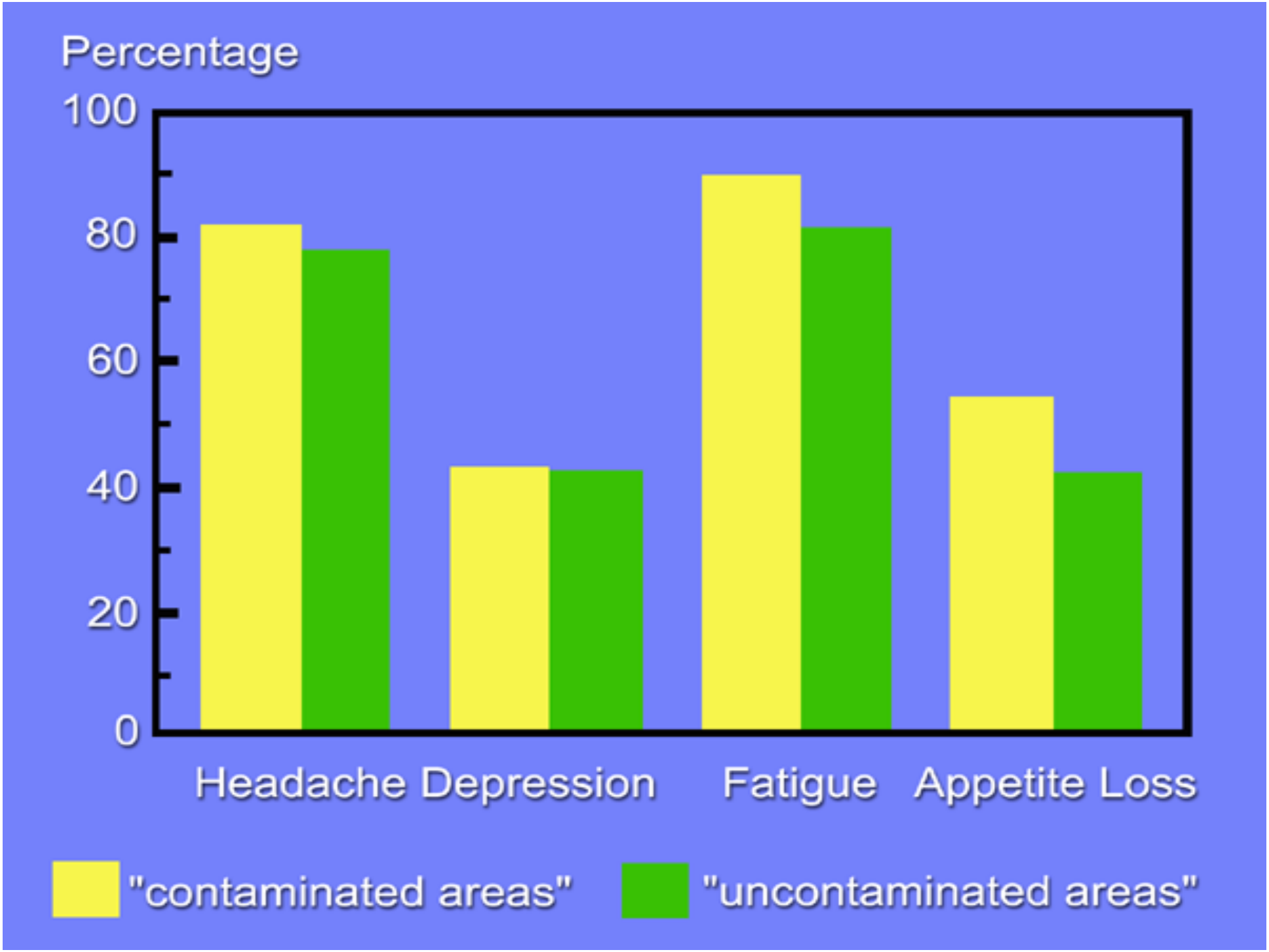
7. Importance of contaminated food


Codex Alimentarious Level
^{137}Cs activity concentrations in non-predatory Bream fish from Kiev reservoirs
Bq/kg, w.w.
1000
900
800
700
600
500
400
300
200
100
0
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000


2000
Bq/l
^{137}Cs activity concentration in milk
Private farms
Collective farms
TPL
1500
1000
Codex Alimentarious Level
500
0
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
Year

8. Importance of psychological effects

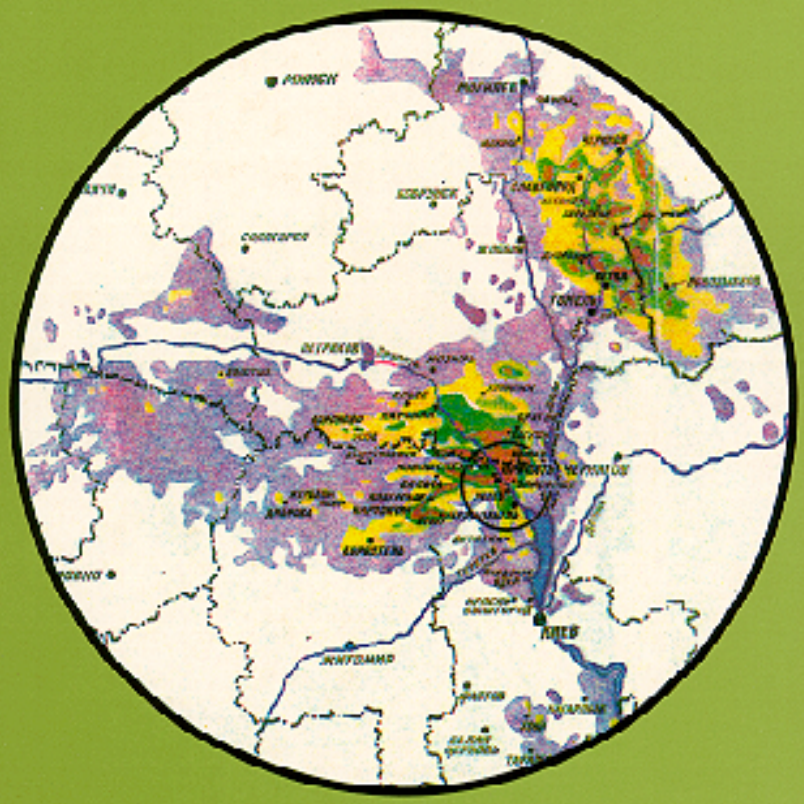

HEALTH
FEARS


Percentage
100
80
60
40
20
0
Headache
Depression
Fatigue
Appetite Loss
"contaminated areas"
"uncontaminated areas"

9. Importance of synthesizing agreements on consequences

THE INTERNATIONAL CHERNOBYL PROJECT

PROCEEDINGS OF AN INTERNATIONAL CONFERENCE



ASSESSMENT OF RADIOLOGICAL CONSEQUENCES
AND EVALUATION OF PROTECTIVE MEASURES

The international conference on

"One decade after Chernobyl:

summing up the consequences of the accident",

which was held in Vienna from 8 to 12 April 1996.

(The conference was co-sponsored by WHO, IAEA and the European Commission in cooperation with the United Nations, the United Nations Scientific Committee on the Effects of Atomic Radiation, the Food and Agriculture Organization of the United Nations, UNESCO and the Nuclear Energy Agency of the Organization for Economic Cooperation and Development.)

Conference Chair:
Angela Merkel

EC IAEA WHO

ONE DECADE AFTER CHERNOBYL

Summing up the Consequences of the Accident

Proceedings of an International Conference
Vienna, 8–12 April 1996

Jointly sponsored by

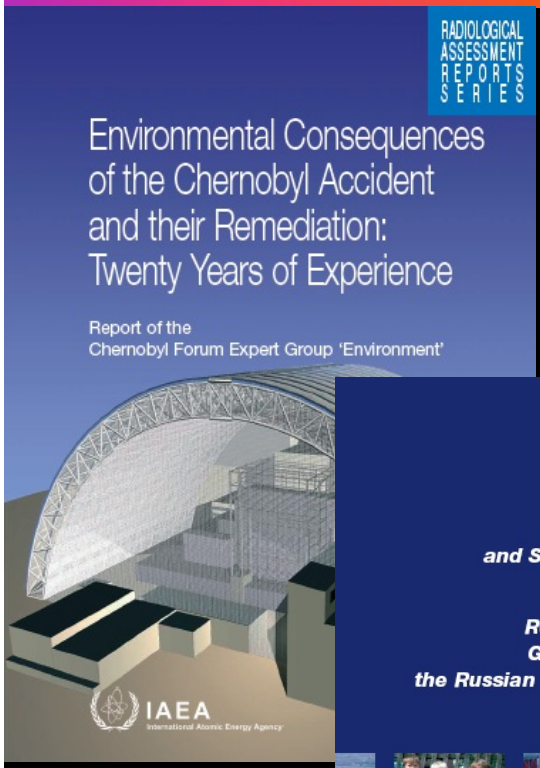
EUROPEAN COMMISSION
INTERNATIONAL ATOMIC ENERGY AGENCY
WORLD HEALTH ORGANIZATION

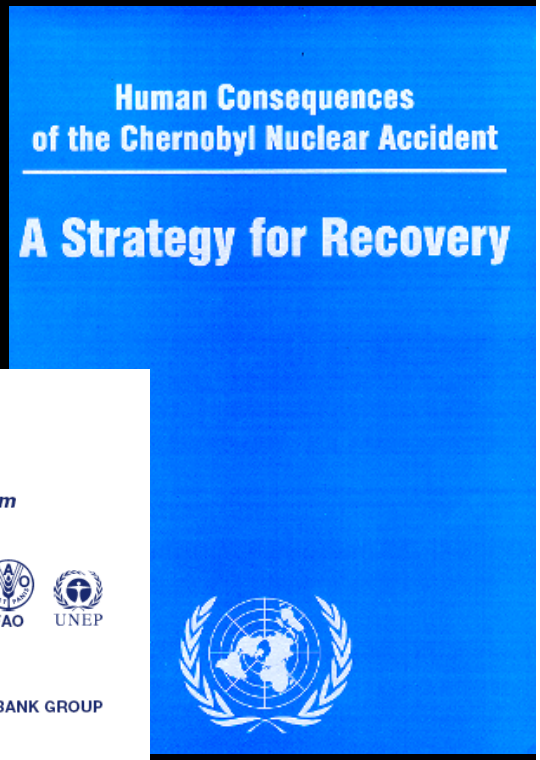
In co-operation with

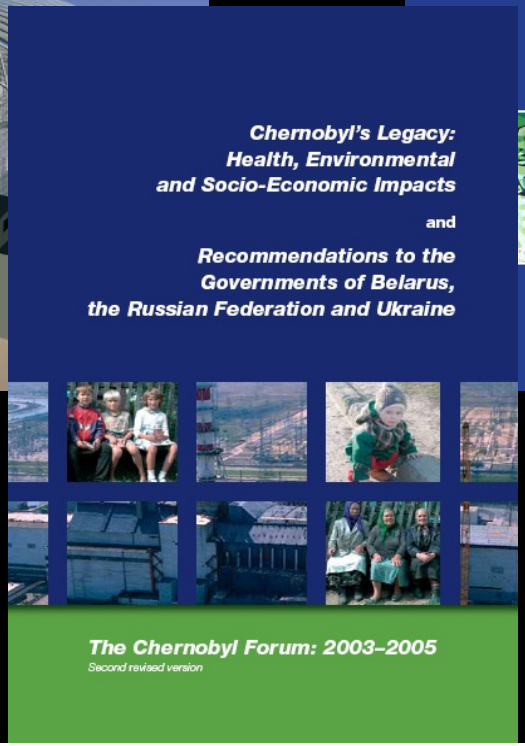
UNITED NATIONS
(DEPARTMENT OF HUMANITARIAN AFFAIRS)
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
UNITED NATIONS ENVIRONMENT PROGRAMME
UNITED NATIONS SCIENTIFIC COMMITTEE ON THE EFFECTS OF ATOMIC RADIATION
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT
(NUCLEAR ENERGY AGENCY)

10. Importance of synthesizing agreements on recovery

Recovery: Chernobyl Forum







2005

The Chernobyl Forum

IAEA WHO FAO UNDP UNEP

UN-OCHA UNSCEAR WORLD BANK GROUP

Belarus

the Russian Federation

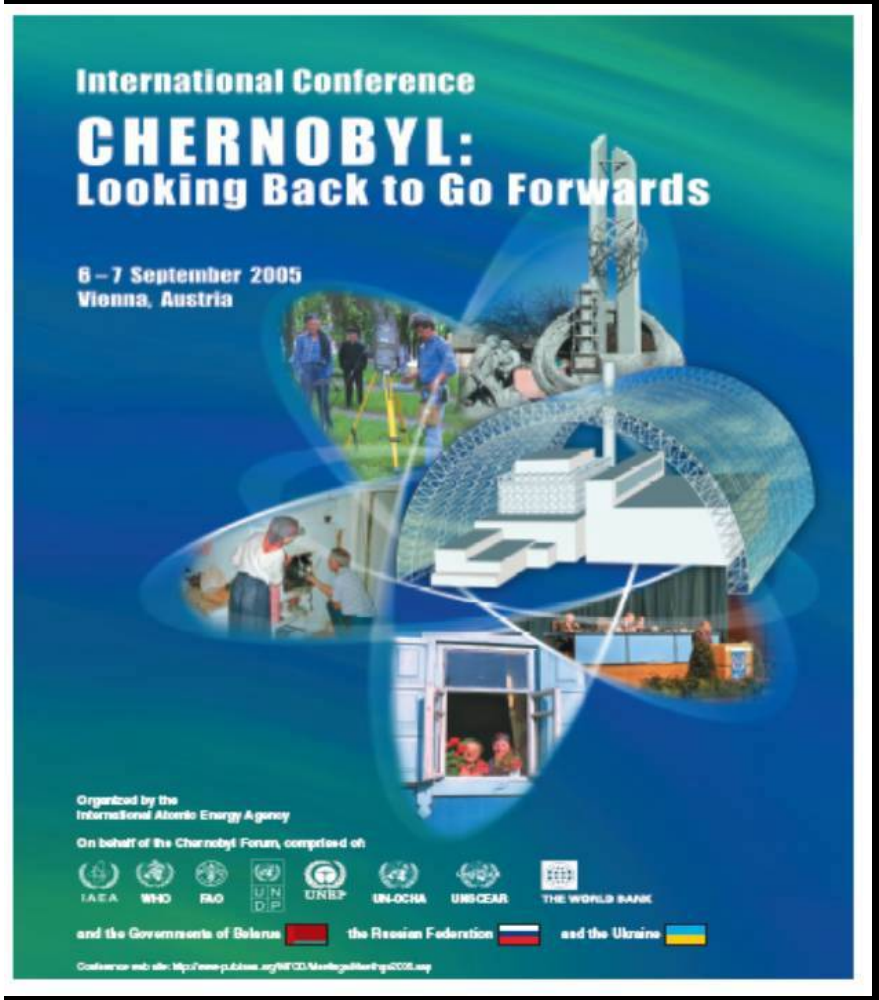
Ukraine

Chernobyl's Legacy:
Health, Environmental
and Socio-economic Impacts

and

Recommendations to the
Governments of Belarus,
the Russian Federation and Ukraine

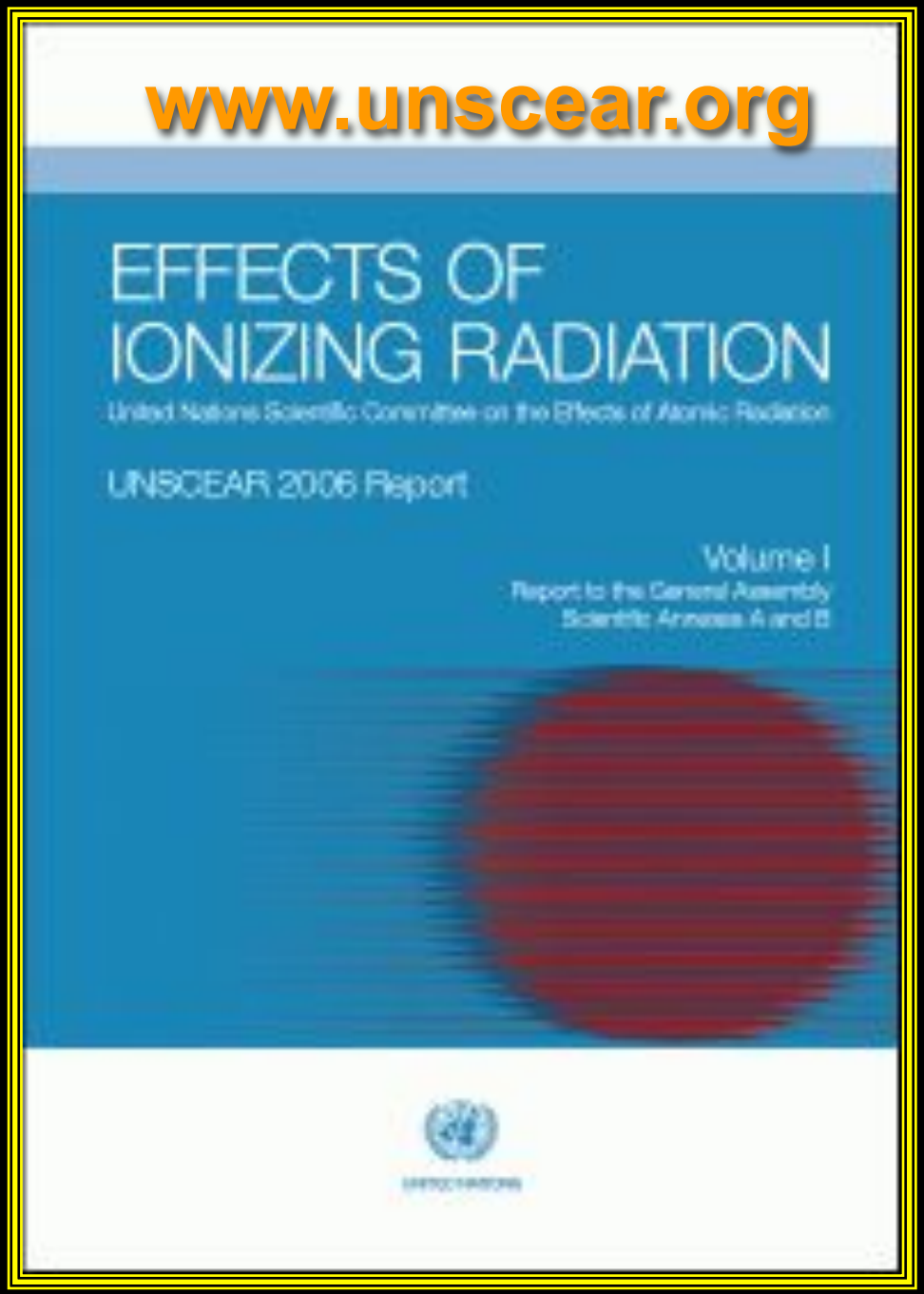
The Chernobyl Forum



The work of the Chernobyl Forum was appraised at an international conference on **"Chernobyl: looking back to go forwards; towards a United Nations consensus on the effects of the accident and the future"**,

which was held in Vienna on 6 and 7 September 2005.

11. Importance of closing the issue internationally



The major conclusions regarding the scale and nature of the health consequences of the Chernobyl accident were submitted to the UN General Assembly.

12. Importance of public information

THE INTERNATIONAL CHERNOBYL PROJECT

ASSESSMENT OF RADIOLOGICAL CONSEQUENCES AND EVALUATION OF PROTECTIVE MEASURES

SUMMARY BROCHURE

On Fukushima

IAEA response

- Convened a Ministerial Conference on Nuclear Safety, which took place in Vienna, on 20-24 June 2011.
- Overall objective was:

  "*to strengthen nuclear safety throughout the world*" [sic]

  rather than identifying and correcting the specific Fukushima deficiencies and provide for the application of its standards in Japan!

The Action Plan

IAEA Atoms for Peace

Board of Governors

GOV/INF/2012/2
Date: 17 February 2012

- An IAEA mission to review Japan's approach for assessing safety.
- Strengthen IAEA peer review services.
- A report highlighting the results of the IRRS missions.
- Coordination and cooperation between the IAEA and WANO;
- 4 OSART missions have been conducted.
- A systematic review of the IAEA Safety Standards.
- Capacity building in Member States with nuclear power programmes and those planning to embark on such a programme has been developed.
- 3 INIR missions have been conducted.
- A web-based platform to strengthen communication has been launched
- A review of INES has been initiated.
- A number of meetings have been held, including:
  - on the IAEA RANET
  - on Nuclear Liability (INLEX)
  - in building the necessary infrastructure for a nuclear power programme; and
  - on the establishment of a Technical and Scientific Support Organizations Forum.

There seems to be a disconnect between the Action Plan and the necessary concentration of efforts on:

- the authoritative identification and correction of the deficiencies that caused Fukushima Daiichi, and
- the protection of people

Why to divert attention to generic nuclear safety issues rather than concentrate efforts on Fukushima?

Why, more than a quarter of a century after Chernobyl, the successful experience is not used in Fukushima?

Parallel International Initiatives

- **UNSCEAR**: Estimate of the global impact
- **WHO**: Assessment of doses incurred
- **ICRP**: Lessons learned

General Assembly

Distr.: General
12 January 2012

Sixty-sixth session
Agenda item 50

Resolution adopted by the General Assembly

[*on the report of the Special Political and Decolonization Committee (Fourth Committee) (A/66/424)*]

66/70. Effects of atomic radiation

The General Assembly,

Acknowledging the concerns about the radiological consequences of an accident which were raised by the accident at the Fukushima Daiichi nuclear power station following the March 2011 earthquake and tsunami in Japan,

5. *Endorses* the intentions and plans of the Scientific Committee for conducting its programme of work of scientific review and assessment on behalf of the General Assembly, in particular its decision to conduct a full assessment of the levels of exposure and radiation risks attributable to the accident following the great east-Japan earthquake and tsunami, calls upon the Scientific Committee to submit to the Assembly at its sixty-seventh session the report requested by the Assembly on the attributability of health effects from radiation exposure,[4] encourages the Scientific Committee at its earliest convenience to submit the other related reports, including on assessments of levels of ionizing radiation from electrical energy production, as well as on the effects on human health and the environment, and requests the Scientific Committee to submit plans for its ongoing and future programme of work to the Assembly at its sixty-seventh session;

World Health Organization

Health action in crises

FAQs: Japan nuclear concerns

Share Print

September 2011

Current risk

What is the current risk of radiation-related health problems in Japan for those residing near the reactor in comparison to those in other parts of Japan?

- During the early phase of the nuclear emergency radiation-related health were dependant on exposure, which is turn were due to several things, including: the amount and type of radiation released from the reactor; weather conditions, such as wind and rain; a person's proximity to the plant; and the amount of time spent in irradiated areas.
- The Government of Japan's early actions in response to events at the Fukushima Daiichi nuclear power plant were in line with the existing recommendations for radiation exposure. The Government has evacuated individuals who were living within a 20-kilometre radius around the Fukushima Daiichi plant. Those living between 20 km and 30 km from the plant were asked to evacuate voluntarily. In general, people living farther away of the site of the event are at lower risk than those who live nearby.

Related links

IOP PUBLISHING JOURNAL OF RADIOLOGICAL PROTECTION

J. Radiol. Prot. 32 (2012) N1–N7 doi:10.1088/0952-4746/32/1/N1

NOTE

The recommendations of the ICRP vis-à-vis the Fukushima Dai-ichi NPP accident aftermath

Abel J González

Autoridad Regulatoria Nuclear (ARN) de Argentina, Avenida del Libertador 8250, AR-1429 Buenos Aires, Argentina

E-mail: agonzalez@arn.gob.ar and abel_j_gonzalez@yahoo.com

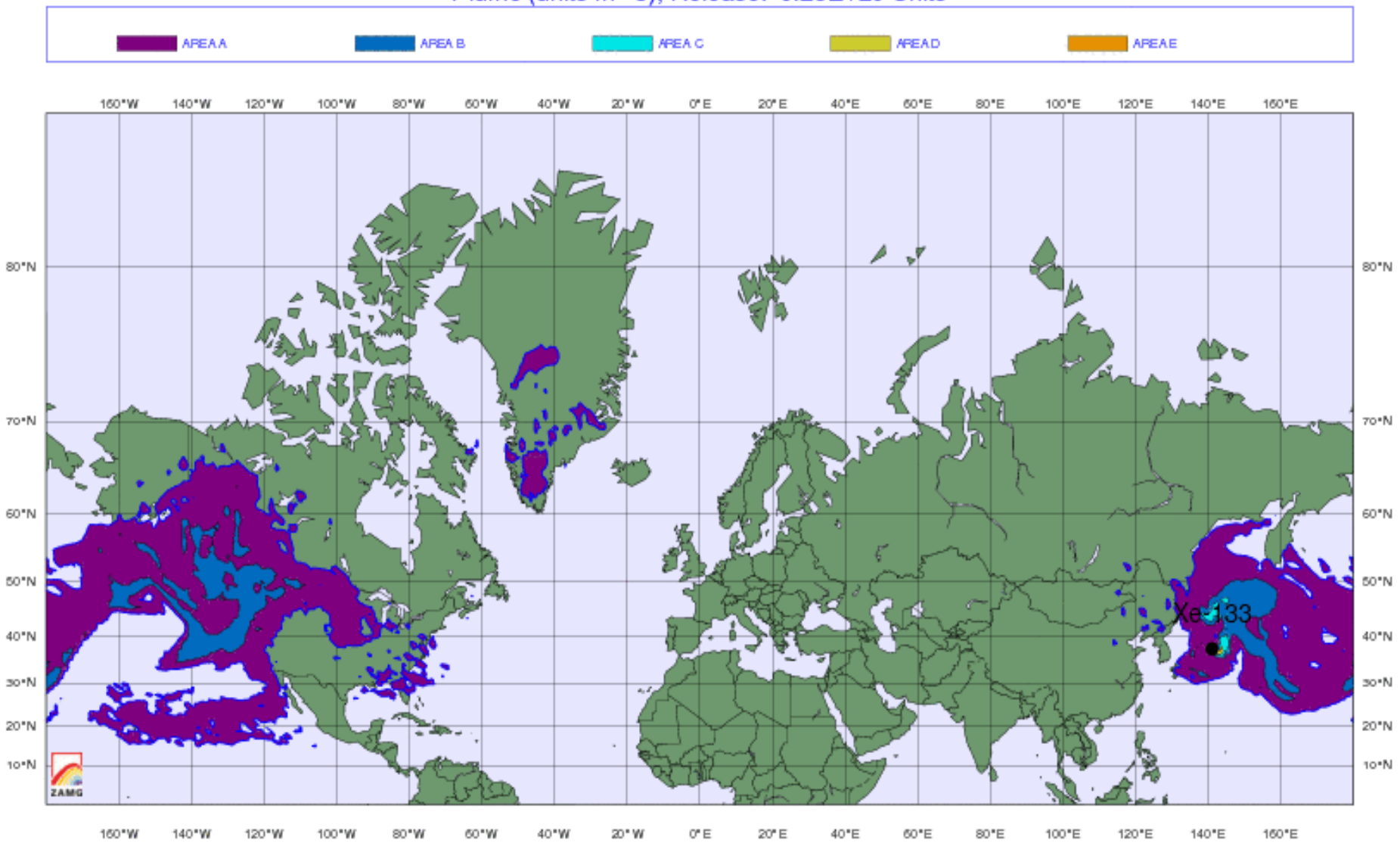
Received 2 February 2012, accepted for publication 5 February 2012
Published 6 March 2012
Online at stacks.iop.org/JRP/32/N1

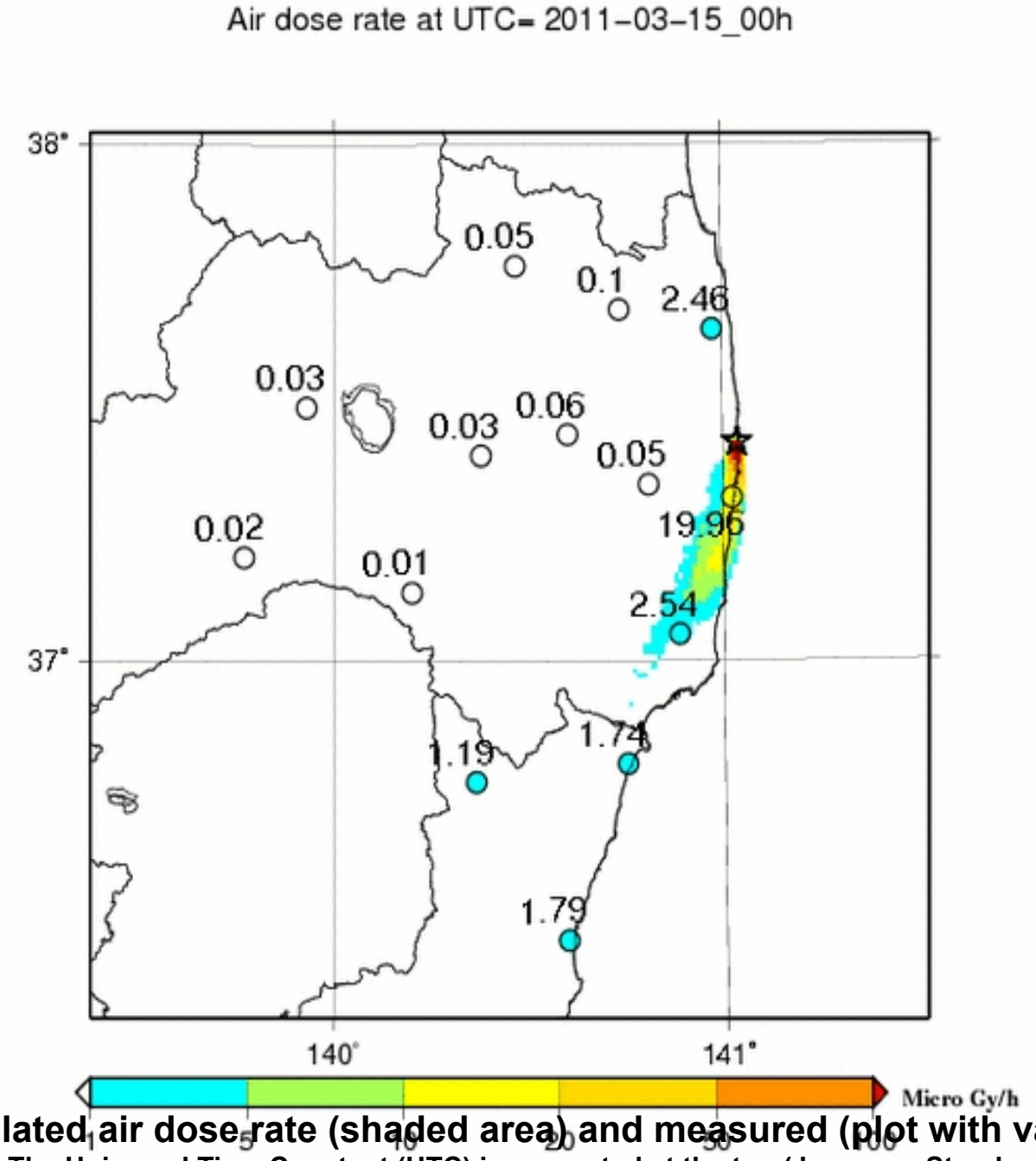

IAEA
Atoms For Peace

Some new lessons already learned for radiation protection!

Specific data from Fukushima

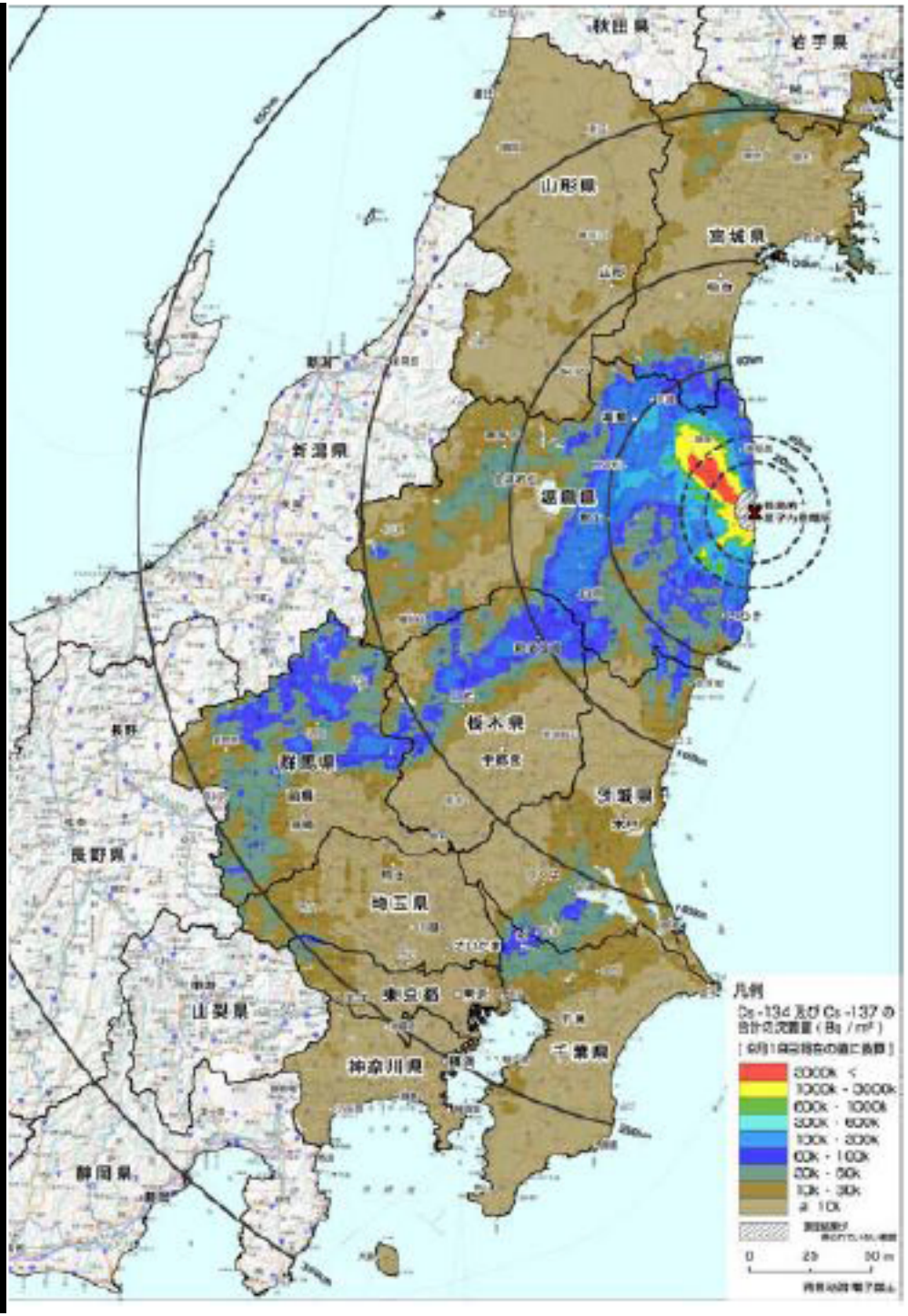
AKW_FUKUSHIMA-Xe-133
20110508-000000
Plume (units m^-3), Release: 0.25E+20 Units





Calculated air dose rate (shaded area) and measured (plot with values) air dose rate]

The Universal Time Constant (UTC) is presented at the top (Japanese Standard Time: + 9 hours).

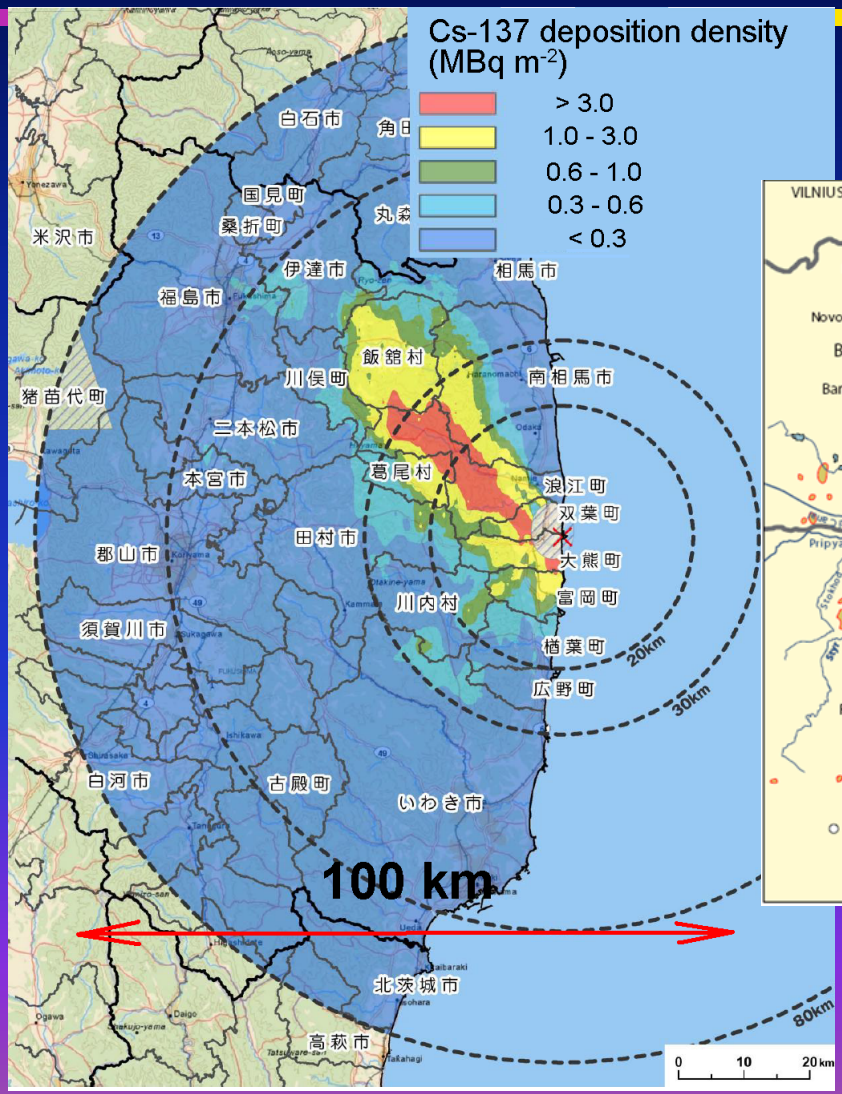

秋田県
岩手県
山形県
宮城県
新潟県
福島県
栃木県
茨城県
群馬県
長野県
埼玉県
東京都
千葉県
山梨県
神奈川県
静岡県
凡例
Cs -134 及び Cs -137 の
合計の沈着量（Bq / m²）
［9月18日現在の値に換算］
3000k ＜
1000k - 3000k
600k - 1000k
300k - 600k
100k - 300k
60k - 100k
30k - 60k
10k - 30k
≦ 10k
測定結果が
得られていない範囲

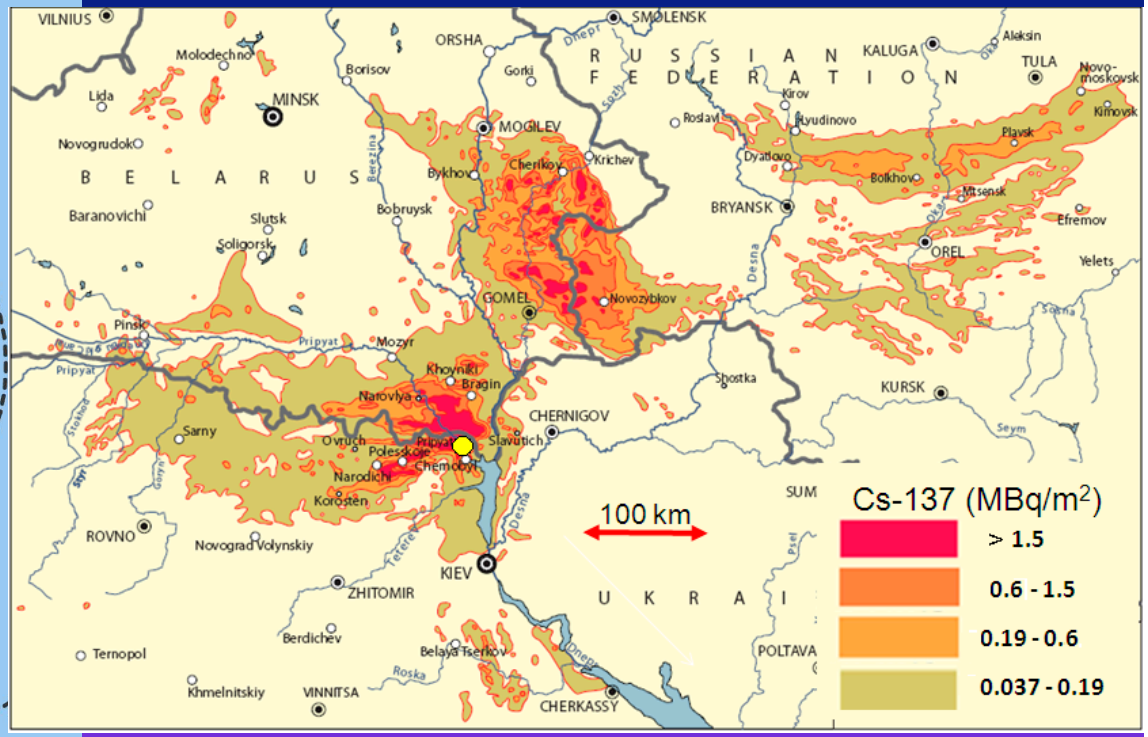
Comparing Fukushima to Chernobyl

Chernobyl

Fukushima

^{137}Cs deposition (MBq m^{-2}) at Fukushima and Chernobyl





276

Areas contaminated with ^{137}Cs around Fukushima and Chernobyl

Accident	Country	Area with ^{137}Cs deposition density (kBq m^{-2})			
		37-185	185-555	555-1480	>1480
Fukushima	Japan	3,248	844	264	132
Chernobyl	USSR	116,900	19,100	7,200	3,100
= times x Fukushima		36	23	27	23

Population size of regions around Fukushima and Chernobyl

	Fukushima	Chernobyl
Evacuees	~100,000 (30-km)	115,000 (30-km)
Highly contaminated areas (^{137}Cs deposition >555 kBq m^{-2})	?	272,000
Less contaminated areas (^{137}Cs deposition 37-555 kBq m^{-2})	?	6,100,000

Countermeasures: evacuation

- Fukushima
  - 10-km zone: 51,000 people (<24 h)
  - 10-20-km zone: 78,000 (1-2 d)
  - 20-30-km zone: voluntary evacuation

- Chernobyl
  - Pripyat-town: 49,400 people (<37 h)
  - 30-km zone: 66,600 people (6-11 d)
  - 30-70-km zone: 17,200 people (> 1 mo)

Whole-body doses

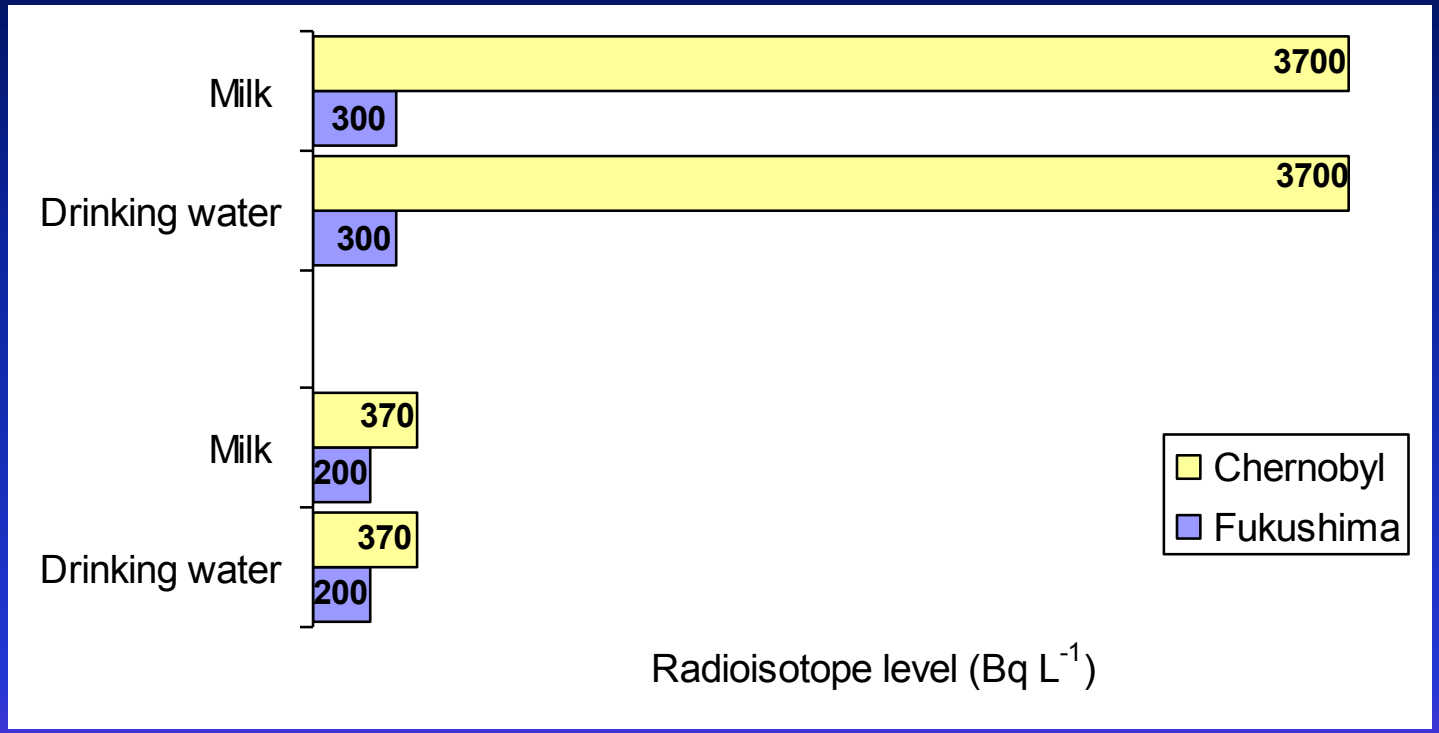
- Fukushima
  - 99.3% of 9,747 people living close to the plant received doses less than 10 mGy (= 10 mSv effective dose)
- Chernobyl (mean whole-body doses)
  - Deposition density of ^{137}Cs >37 kBq/m^2: 10 mGy
  - Deposition density of ^{137}Cs >555 kBq/m^2 : 50 mGy
  - 30-km zone: 33 mGy

Fukushima dose bands

- More affected locations of Fukushima prefecture (examples, committed dose from the first 4 months only)
  - Namie, Iitate: 10-50 mSv;
  - Katsurao, Minami-Soma, Naraha, Iwaki: 1-10 mSv
- Rest of Fukushima prefecture: 1-10mSv
- Neighbouring prefectures: 0.1-10 mSv

Countermeasures:

Regulated values of radioactive materials in food (Bq / kg)



Highest measured ^{131}I concentration in milk:

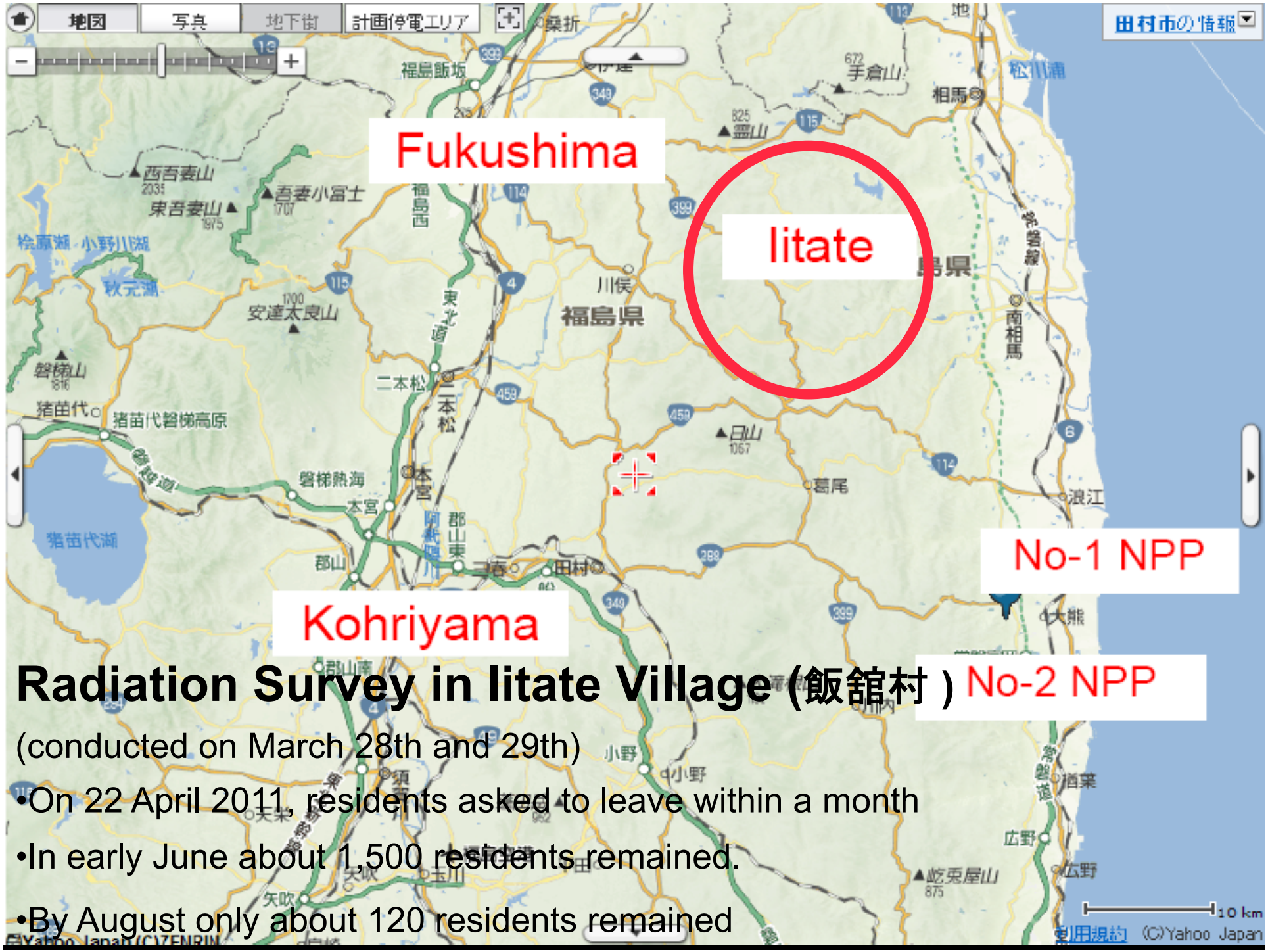
- **Fukushima: 5,300 Bq L^{-1} in Fukushima prefecture**
- **Chernobyl: ~ 300,000 Bq L^{-1} in 30-km zone in Belarus**

Thyroid dose bands (mSv)

- More affected locations of Fukushima prefecture (examples, committed dose from the first 4 months only)
  - Namie: 10-100 adults and 10y; 100-200 1y;
  - Katsurao, Minami-Soma, Naraha: 10-100 all ages
  - Iwaki: 1-10 adults; 10-100 for 10y and 1y
- Rest of Fukushima prefecture (less affected): 1-10 adults; 10-100 for 10y and 1 y
- Neighbouring Japanese prefectures: 1-10

Special problem

litate - 飯舘村

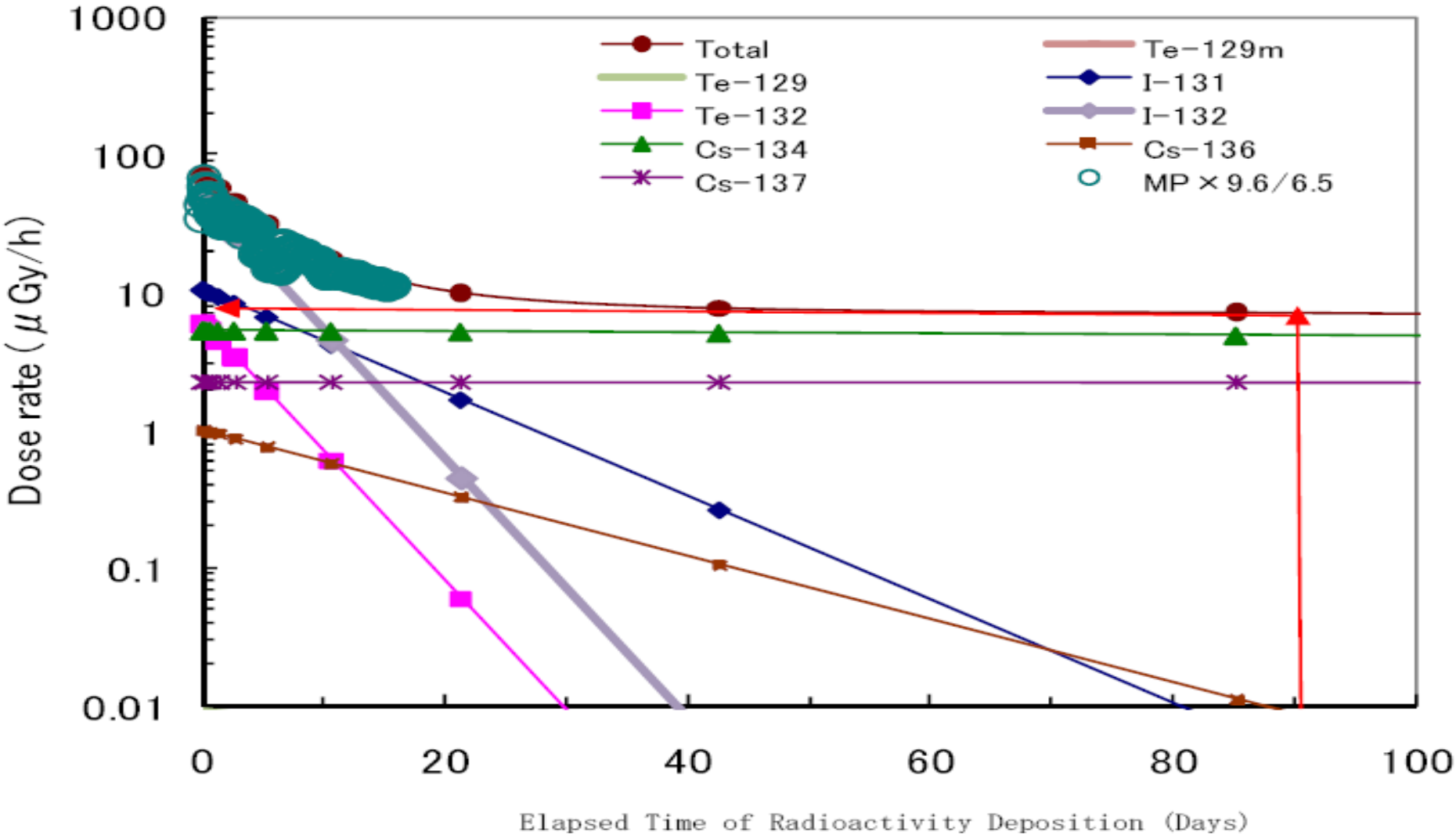


Radiation Survey in Iitate Village (飯舘村)

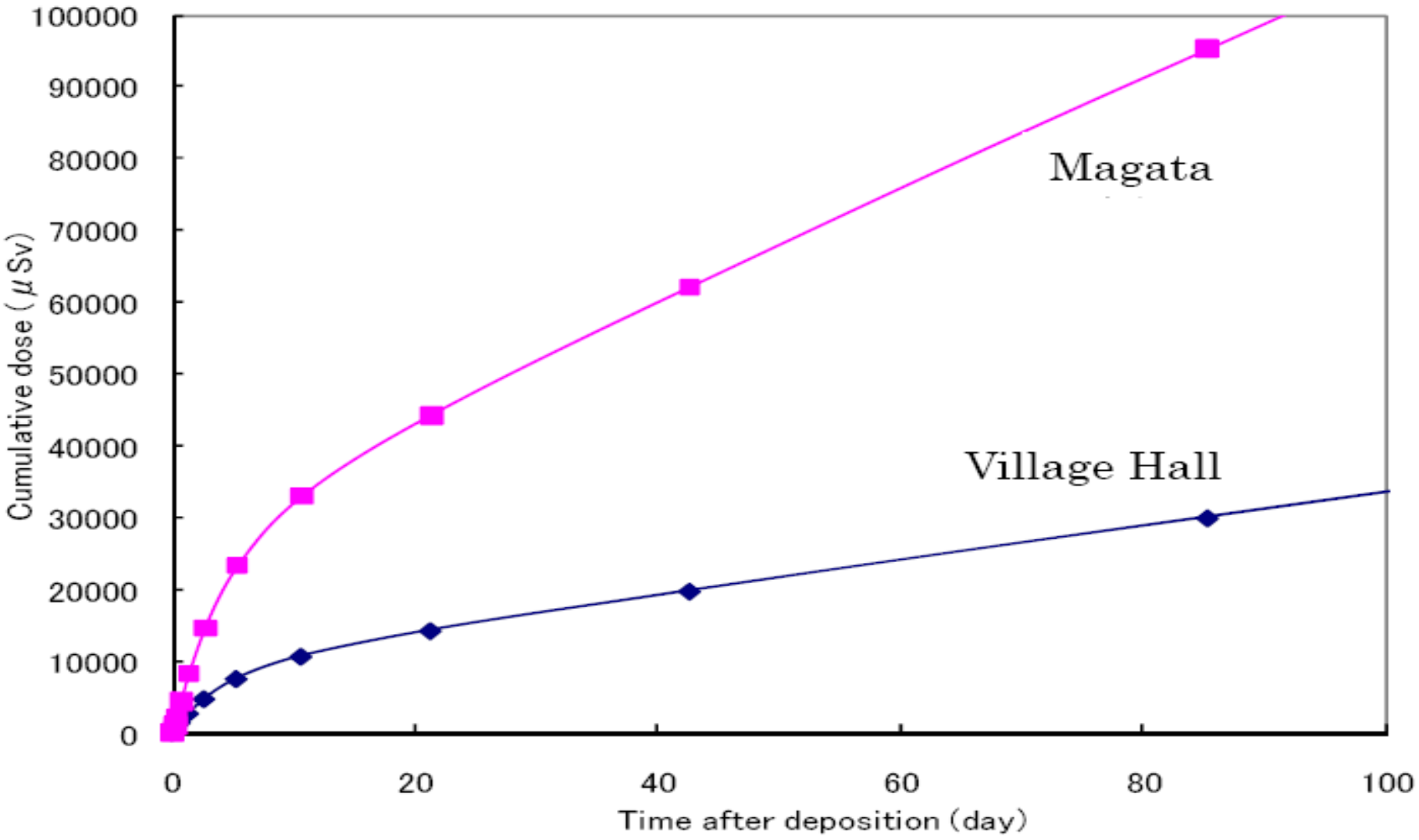
(conducted on March 28th and 29th)

- On 22 April 2011, residents asked to leave within a month
- In early June about 1,500 residents remained.
- By August only about 120 residents remained

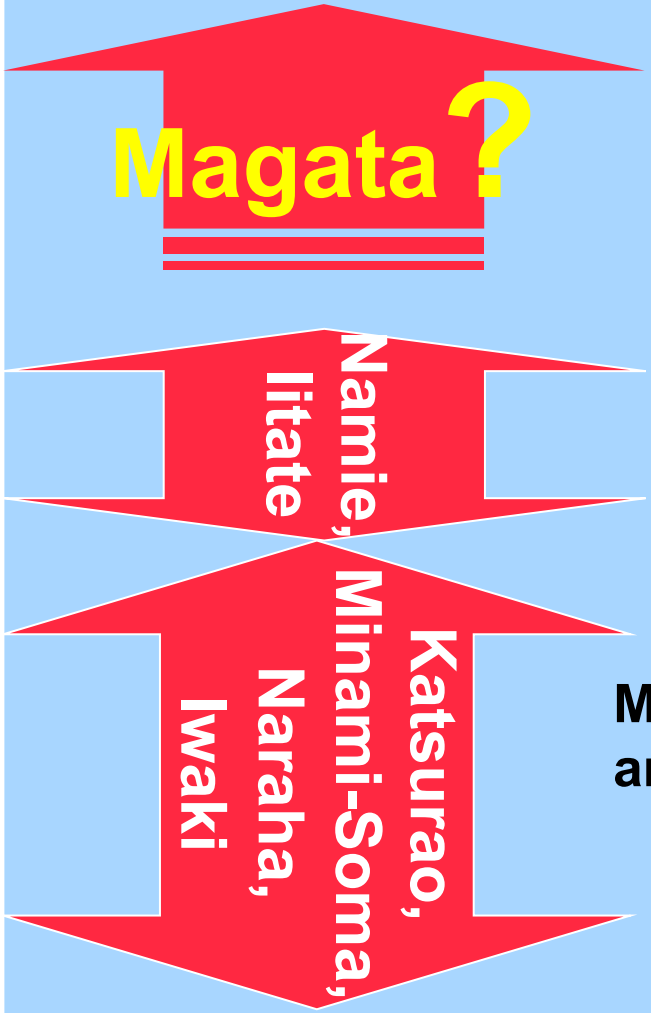
Variation of Air Radiation Dose Rate in Iitate Village Office (7 μ Gy/h after 3 months)



Cumulative Dose at Iitate Village Office and Magata



Natural Background



annual dose
mSv/year

Few people
In few areas ⇒ ~100

VERY HIGH

Many people
In many areas ⇒ ~ 10

TYPICALLY HIGH

Majority of people
around the world ⇒ ~ 2.4

AVERAGE

~ 1

MINIMUM