Radon in the NORM industry in Belgium

Federal Agency for Nuclear Control

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FANC ?

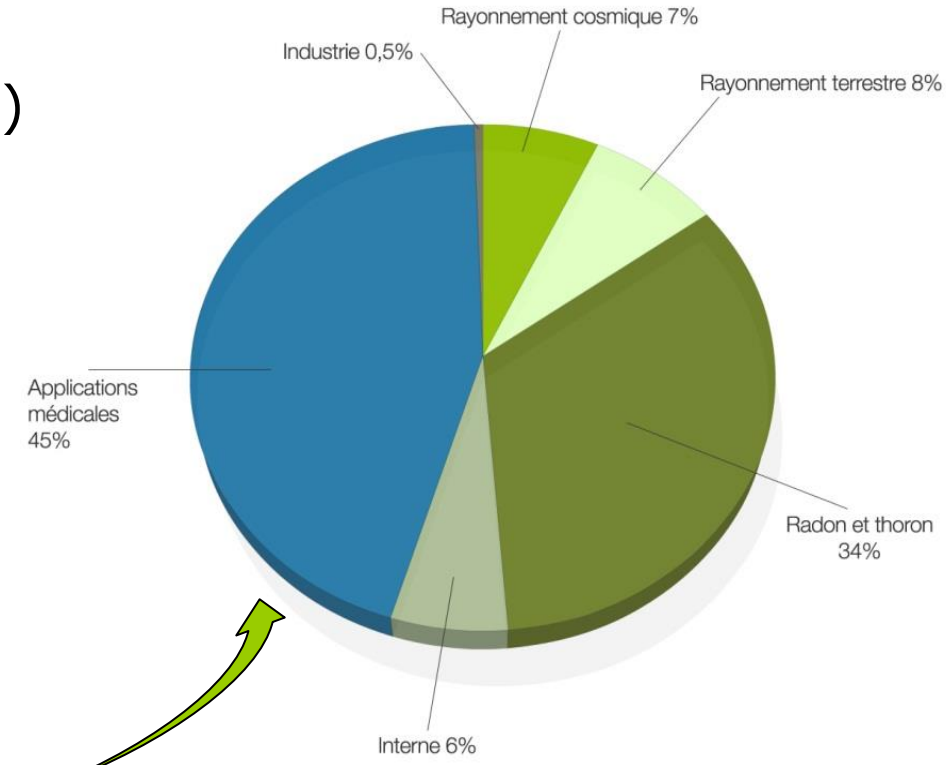
Federal Agency for Nuclear Control

Protection of the **population**, the **workers** and the **environment** against the dangers from ionizing radiation

- **150 collaborators**

(engineers, physicians, physicists, …)

- 6 points of attention:
  - Nuclear **Installations**
  - Radioactive **waste**
  - **Security**
  - **Transport**
  - Protection of **health**
  - **Surveillance** of the territory and natural radiation



Belgian NORM regulations

Directive 96/29/EURATOM (European Basic Safety Standards, now being replaced by **2013/59/Euratom**

Transposed into Royal Decree of July, 20 2001 (currently under review)

Art.4 lists "*work activities involving natural radiation sources*"

Art.9: industries are submitted to **notification**

Objective of notification: dose-impact assessment (workers and population)

Impact workers + population must be < 1 mSv/a

– if not, **corrective measures** or **licensing.**

Belgian RADON regulations

Directive 96/29/EURATOM (European Basic Safety Standards, now being replaced by **2013/59/Euratom**

Transposed into Royal Decree of July, 20 2001 (currently under review)

Art.4 defines "*workplaces with a risk of radon exposure*": waterworks, educational and health institutes, underground workplaces, caves, …all workplaces in the areas defined by FANC

Art.9: these workplaces are submitted to **notification**

Objective of notification: dose-impact assessment (workers and population)

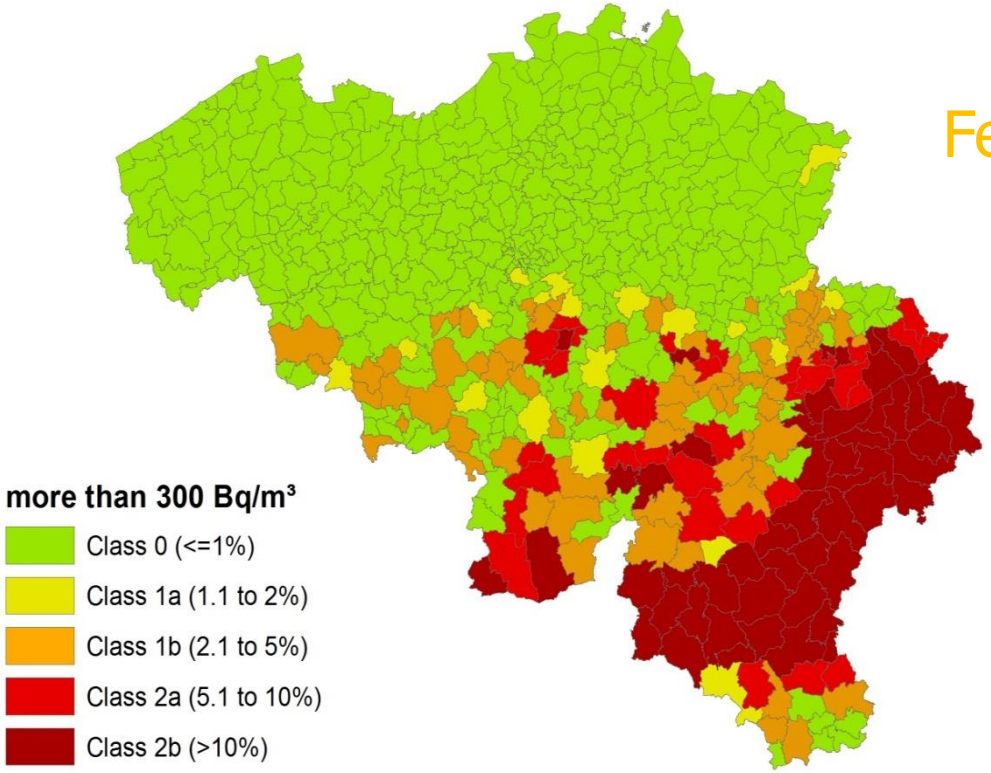
Impact from radon must be < 3 mSv/a or 800 kBqh/m³

– if not, **corrective measures** or **licensing.**

List of NORM work activities

Sector	Radon issue
Groundwater treatment facilities	x
Storage, handling and processing of **zircon and zirconia**	
Storage, handling and processing of **phosphate ores**	X
Production of **non-ferrous metals**	X
processing, valorization and recycling **of NORM residues**	X
Production, storage, use and handling of **thorium-based materials**	
Extraction and transport of **natural gas** and **shale-gas**	X
Titaniumdioxide production	
Primary production of **rare earths**	
Coal-fired power plant	
Oil reffineries	
Geothermal energy – including exploration phase	X
Distribution of **consumer products** with an activity concentration above RP 122	
Primary **iron** production	
Decommissioning and recycling of **zircon(ia)-based refractories**	
Storage, handling and processing of **pyrochlore, columbite, tantalite, ilmenite, rutile, cassiterite, monazite, garnet and silica fumes**	

Defining the Radon Risk areas Introduction of Reference Level of 300 Bq/m³ following the EU BSS



February 2018

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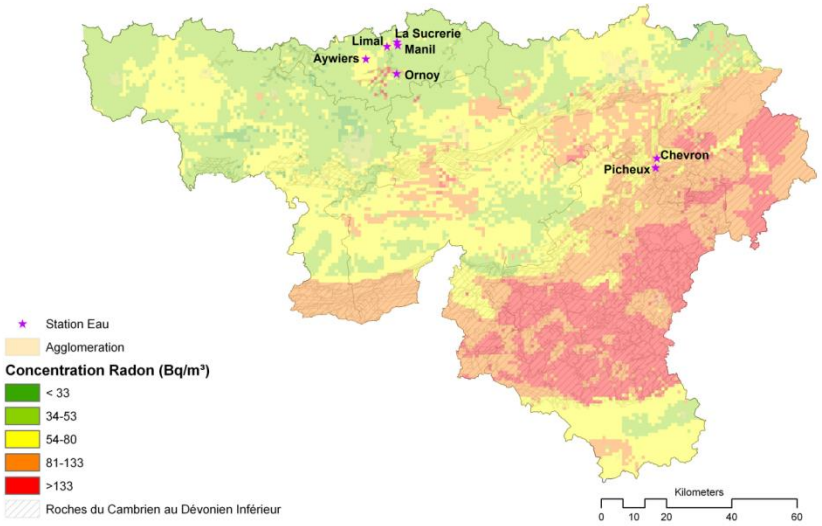
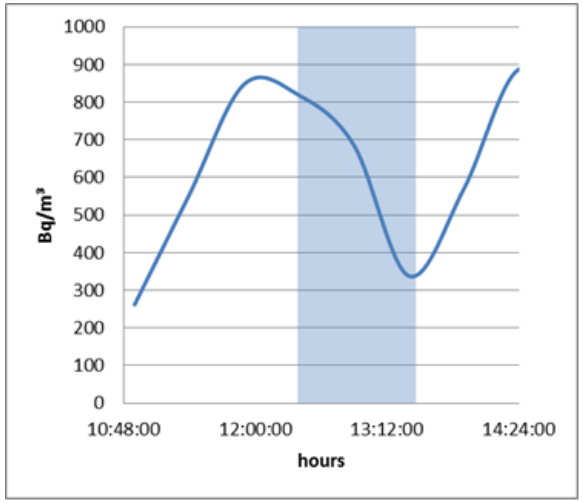
Groundwater treatment and waterworks



Station	Aquifer geology	Depth of the capture point (m)	External gamma dose rate (range in nSv/h)	Radon in air (range in Bq/m³)	Radon in water (range in Bq/l)
1 Or	Sand	10	70 – 120	50 - 2300	2 – 12
2 Lim	Sand	10	80- 120	100 - 600	2 - 3
3 Sucre	Chalk	70	90 – 200	60 - 1200	7 – 30
4 Mini	Chalk	40	/	100 - 550	12 – 45
5 Chev	Quartzite	87	150 – 500	400 - 2100	45 - 55
6 Aywi	Black shale	60	200 – 2800	2500 - 8000	27 - 55
7 Genv	Chalk	45	80 – 120	150 - 445	5 - 15
8 Sauv	Black shale	100	60 - 270	6000 - 12000	55 - 58
9 Sart	Limestone	91	50 - 70	140 - 290	5 - 8



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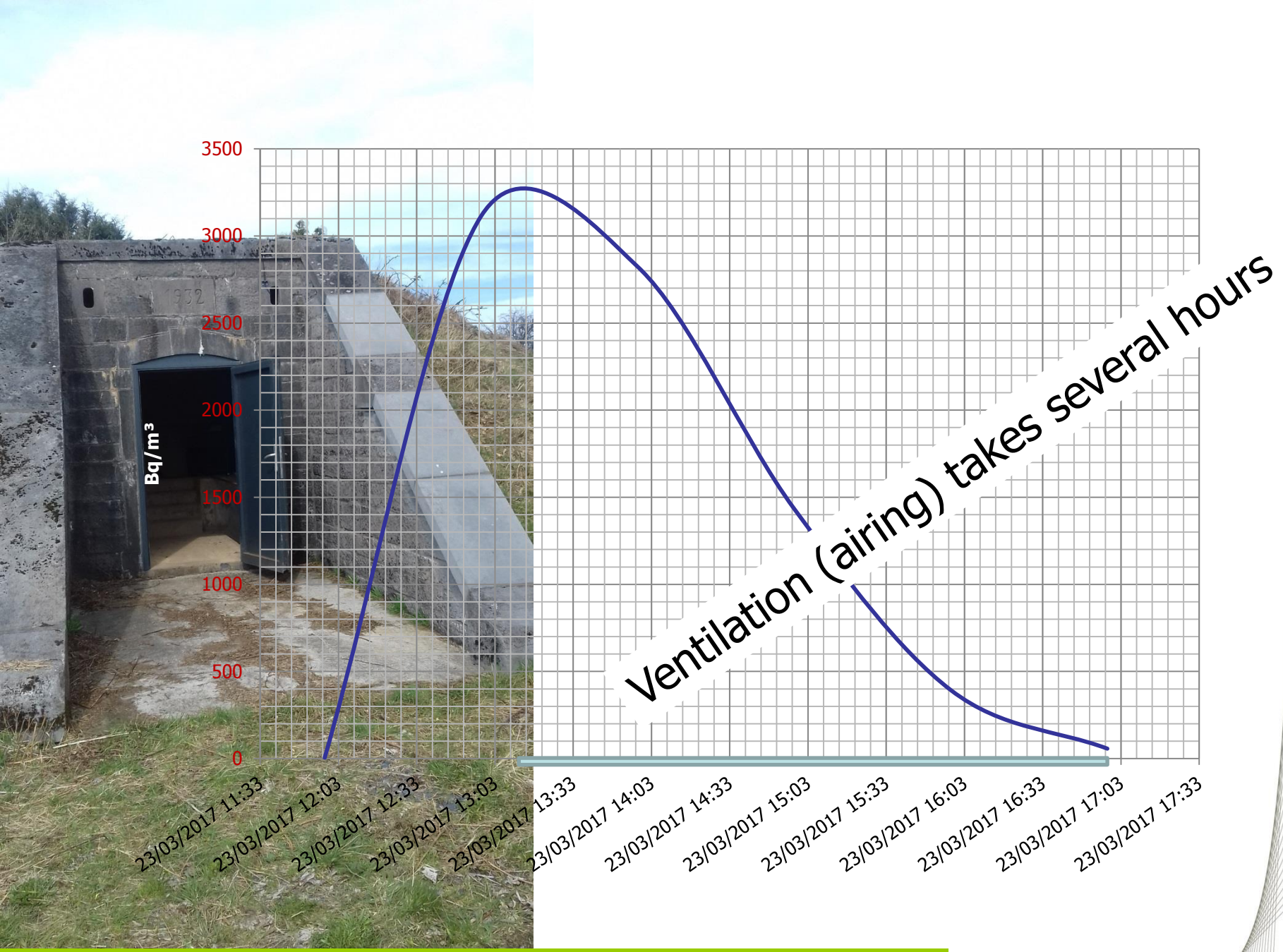
3500
3000
2500
2000
1500
1000
500
0
Bq/m³
Ventilation (airing) takes several hours
23/03/2017 11:33
23/03/2017 12:03
23/03/2017 12:33
23/03/2017 13:03
23/03/2017 13:33
23/03/2017 14:03
23/03/2017 14:33
23/03/2017 15:03
23/03/2017 15:33
23/03/2017 16:03
23/03/2017 16:33
23/03/2017 17:03
23/03/2017 17:33

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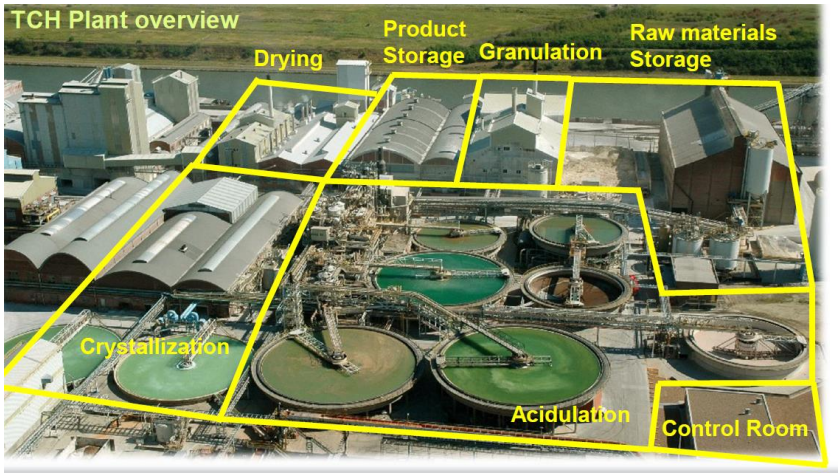
Radon in the Phosphate Industry

- Outdoor
  - Tailing ponds
  - Contaminated areas
- Indoor
  - Filter press buildings
  - Build-on parcels in Contaminated areas



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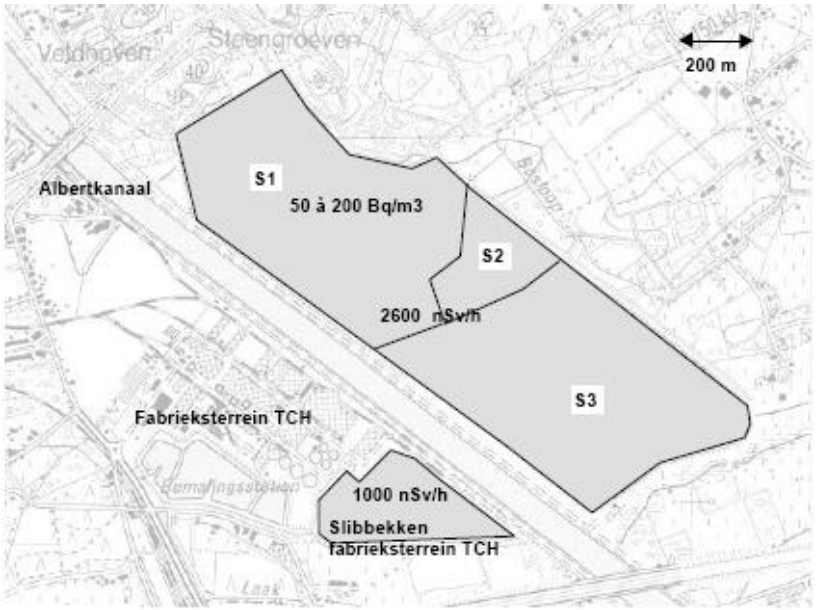
Tailing ponds

Mechanical dewatering of sludge via filter-press

Filter-cake (with Ra) disposed on sludge deposit site



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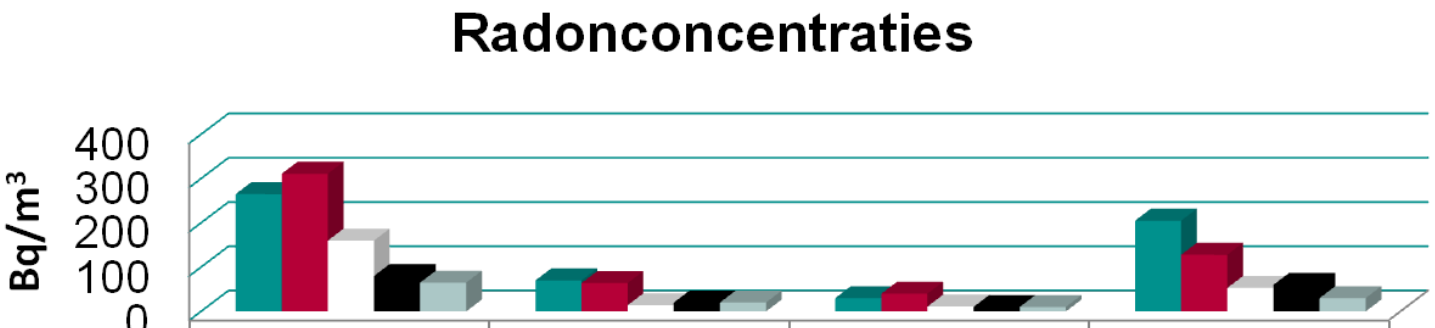
Radon in open air – 14 measurements points on and around The tailing pond (1.5 m high)



	Op en nabij S1+S2	Op S3	Omgeving slibbekken	punt 11 slibbekken TCH
2006	265	70	30	205
2007	311	64	40	128
2008	160	14	11	53
2009	80	20	10	60
2010	65	20	10	30

Radonconcentraties

	Op en nabij S1+S2	Op S3	Omgeving slibbekken	punt 11 slibbekken TCH
2009	80	20	10	60
2010	65	20	10	30
2011	78	25	15	83
2012	60	15	10	45
2013	45	20	10	43

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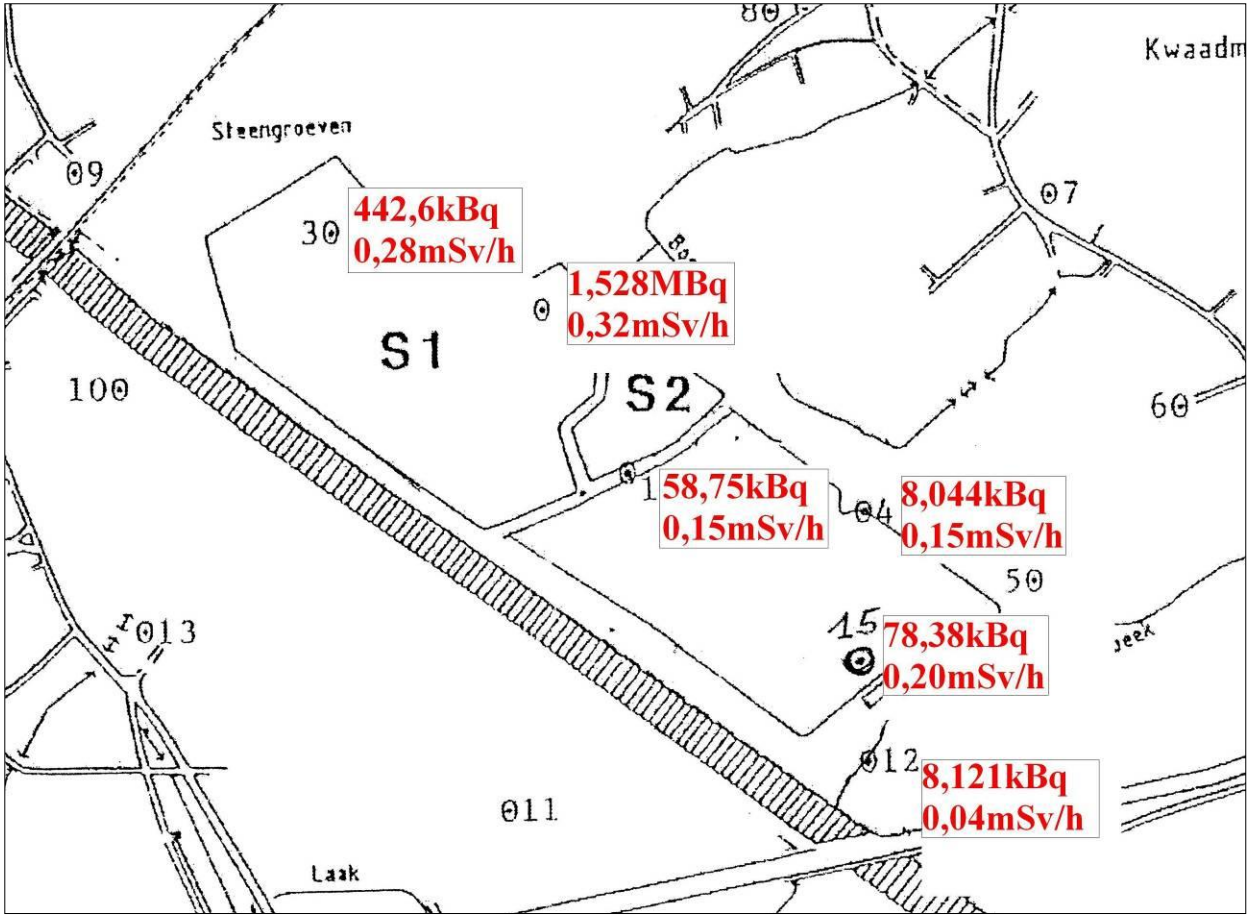
radon in soil measurements



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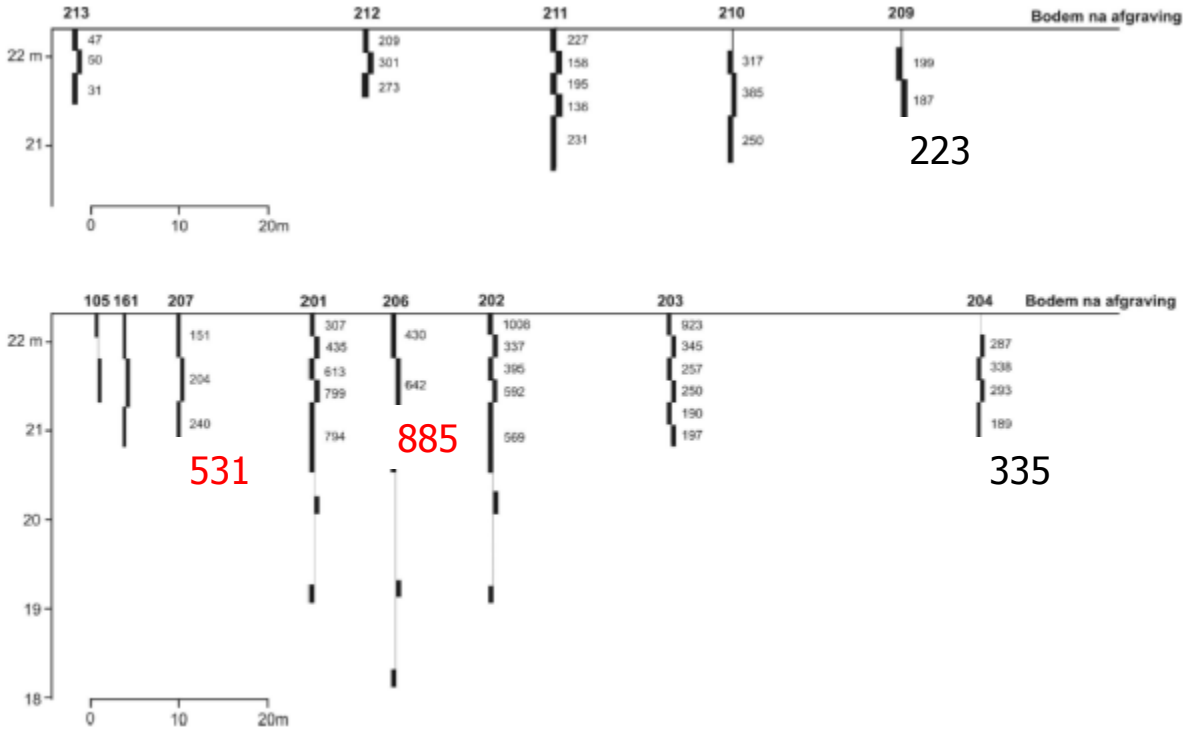
Contaminated matrices: *sediments* (~ 3 Bq/g Ra-226),
Soil (up to ~ 5m deep – locally 10m) up to 900 Bq/kg

=> Profile of radium concentration of the natural soil under the waste water basin (after removal of the sludge)



Figuur 10 Concentraties radium (Bq/kg) in de natuurlijke bodem onder het afgegraven slib (zonder hoogtecorrectie) (Milieulabo TC, Dr. P. Luts)

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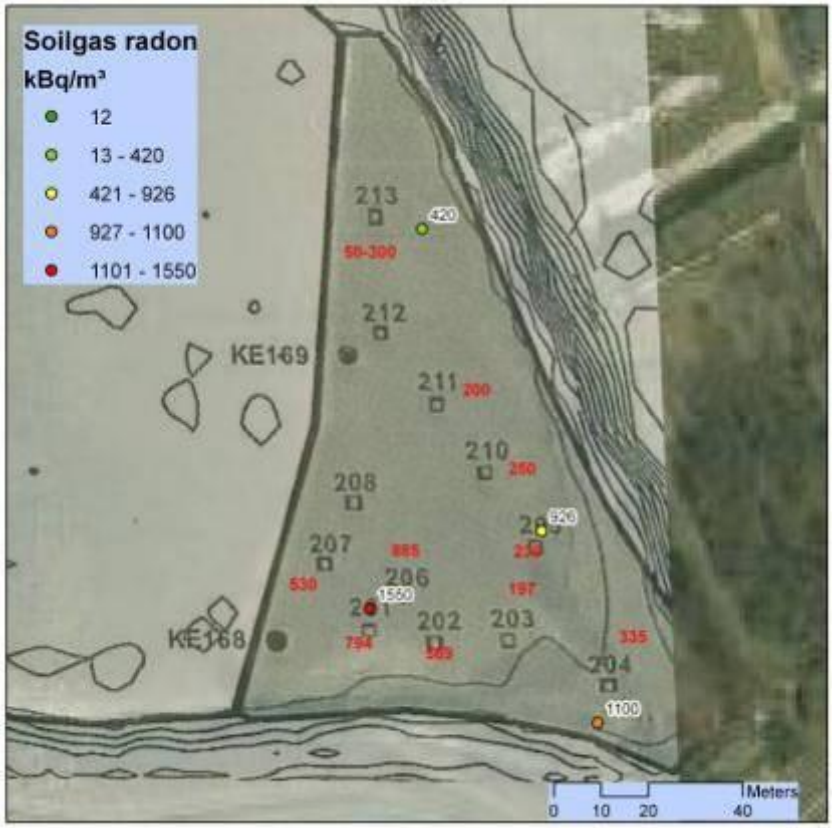
Radon in soil between 420 and 1550 kBq/m^3

Radon in soil between 420 and 600 kBq/m^3

Normal values in the area = 10 to 20 kBq/m^3

High values in the Ardennes = 100 to 300 kBq/m^3



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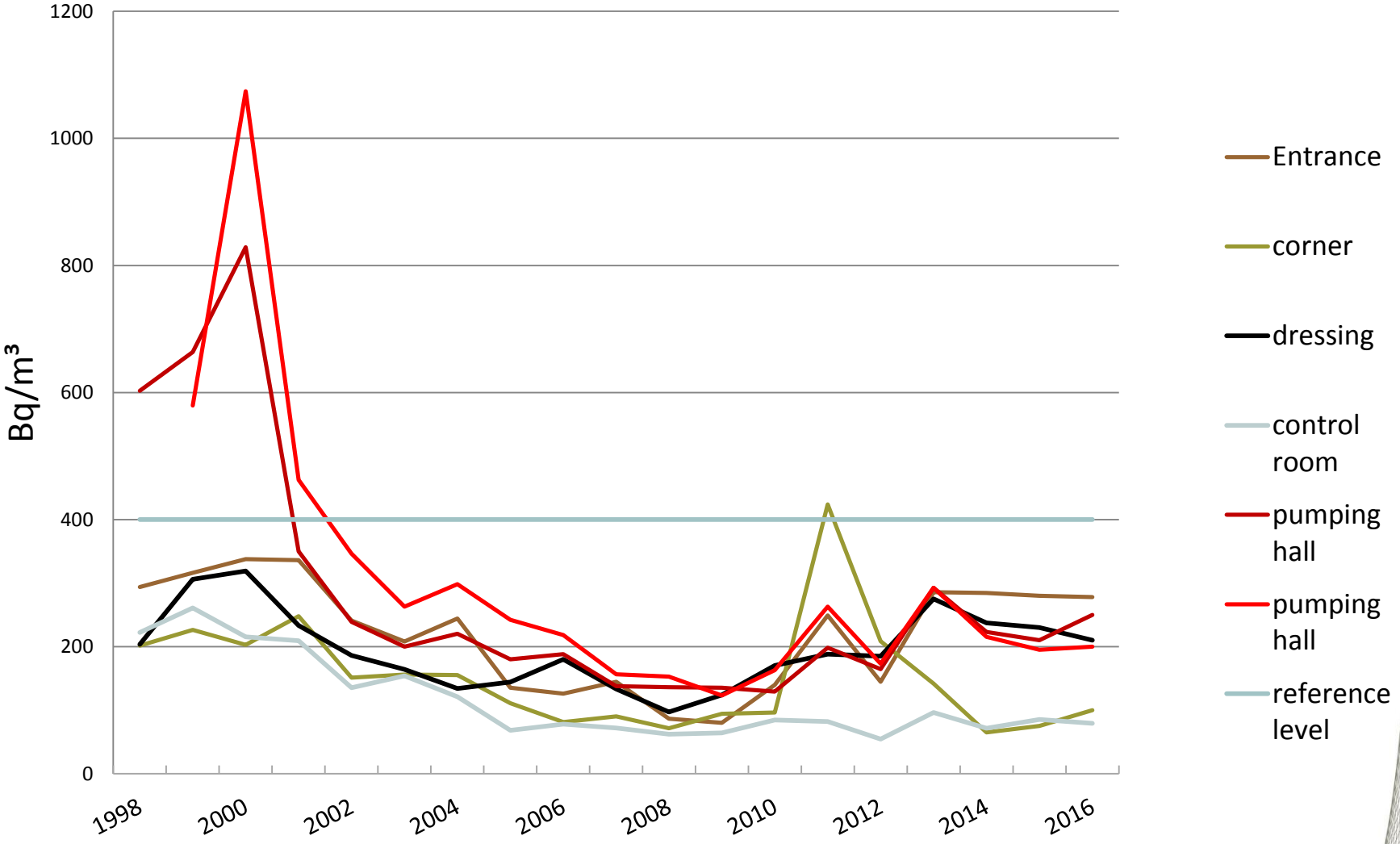
Radon in the Filter press building



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NORM legacy and environmental contamination

FANC decree of 30 November 2015 (original 10 august 2011) :

Define the areas with increased radon risk

AGENCE FEDERALE DE CONTROLE NUCLEAIRE

F. 2011 — 2476 [C − 2011/00542]

10 AOUT 2011. — Arrêté de l'Agence fédérale de Contrôle nucléaire fixant les zones à risque et les zones visées respectivement au articles 4 et 70 de l'arrêté royal du 20 juillet 2001 portant règlement général de la protection de la population, des travailleurs et de l'environnement contre le danger des rayonnements ionisants

FEDERAAL AGENTSCHAP VOOR NUCLEAIRE CONTROLE

N. 2011 — 2476 [C − 2011/00542]

10 AUGUSTUS 2011. — Besluit van het Federaal Agentschap voor Nucleaire Controle houdende de vaststelling van de risicozones en de zones bedoeld in respectievelijk de artikelen 4 en 70 van het koninklijk besluit van 20 juli 2001 houdende algemeen reglement op de bescherming van de bevolking, van de werknemers en het leefmilieu tegen het gevaar van de ioniserende stralingen

Geogenic radon risk areas: natural risk

Antropogenic radon risk areas:

Zone for which on the basis of measurements or other data that FANC disposes of, it can be estimated that more then

5% of buildings the radon action level will be passed

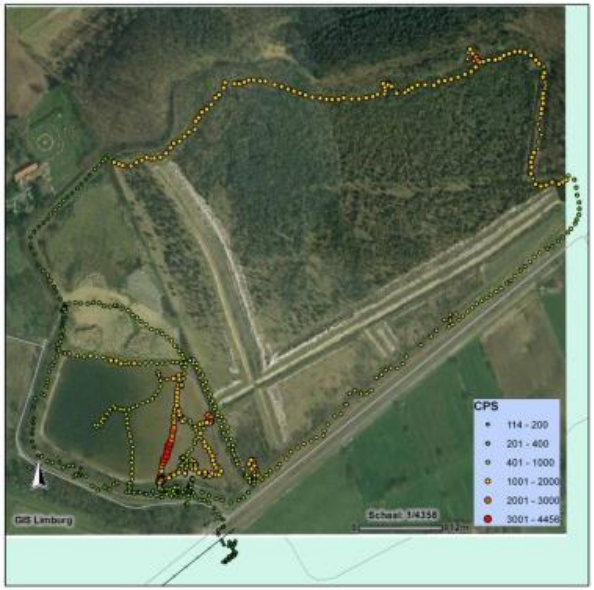
"Antropogenic" radon prone areas

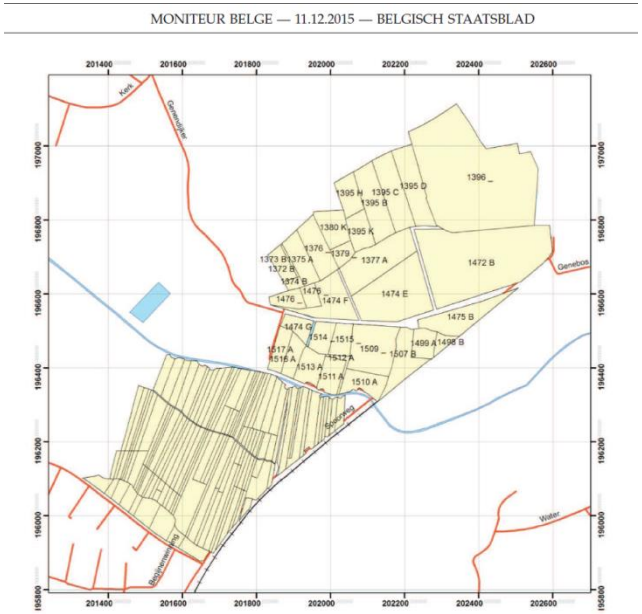
Radium contaminated sites considered as "**antropogenic radon prone areas**"

⇒ Include e.g. all known phosphogypsum stacks (for instance, Rupel area)

⇒ list of cadastral percel published in Belgian Official Journal (11/12/2015)

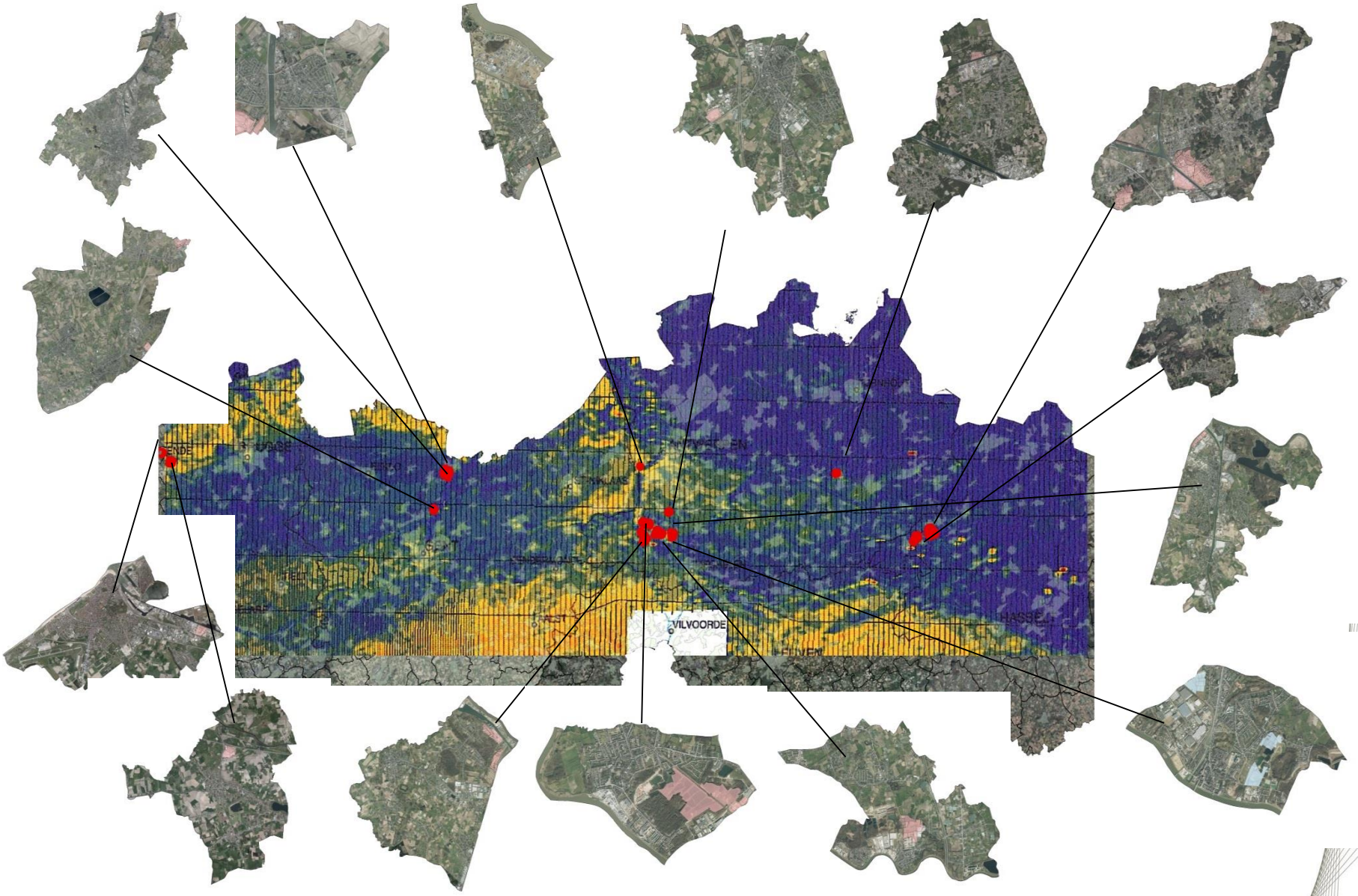
⇒ Obligation of taking into account radon risk in the redevelopment of the site (prevention measures, monitoring)





Tessenderlo Spoorwegstraat/ Ham Kepkensberg

- In total 15 sites :



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Radon on the gypsum stacks

- Concentrations from 500 Bq/kg to 1000 Bq/kg Radium.
- Exhalation of radon
- Risk of indoor radon exposure

typical phosphogypsum				
radium in the soil (Bq/kg)	emanation coefficient (fraction)	density (kg/l)	porosity (%)	[Rn] (kBq/m³) calculated from [Ra]
500	0,3	2,5	0,48	781,25

estimated soil air flow trough cracks into the room(m³/h)	radon in the soil (Bq/m³)		Radon flow from soil to room (Bq/h)	fresh air trough ventilation in the room (m³/h)			indoor radon estimated steady state (Bq/m³)
0,05	781250		39063	75			521

Houses on gypsum stacks measured: up to 400 Bq/m³

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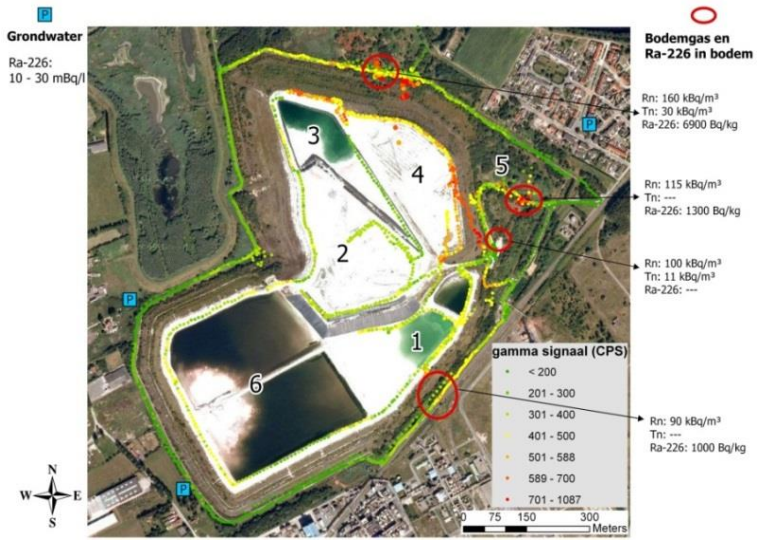
Remediation of phosphogypsum stack into solar panel park

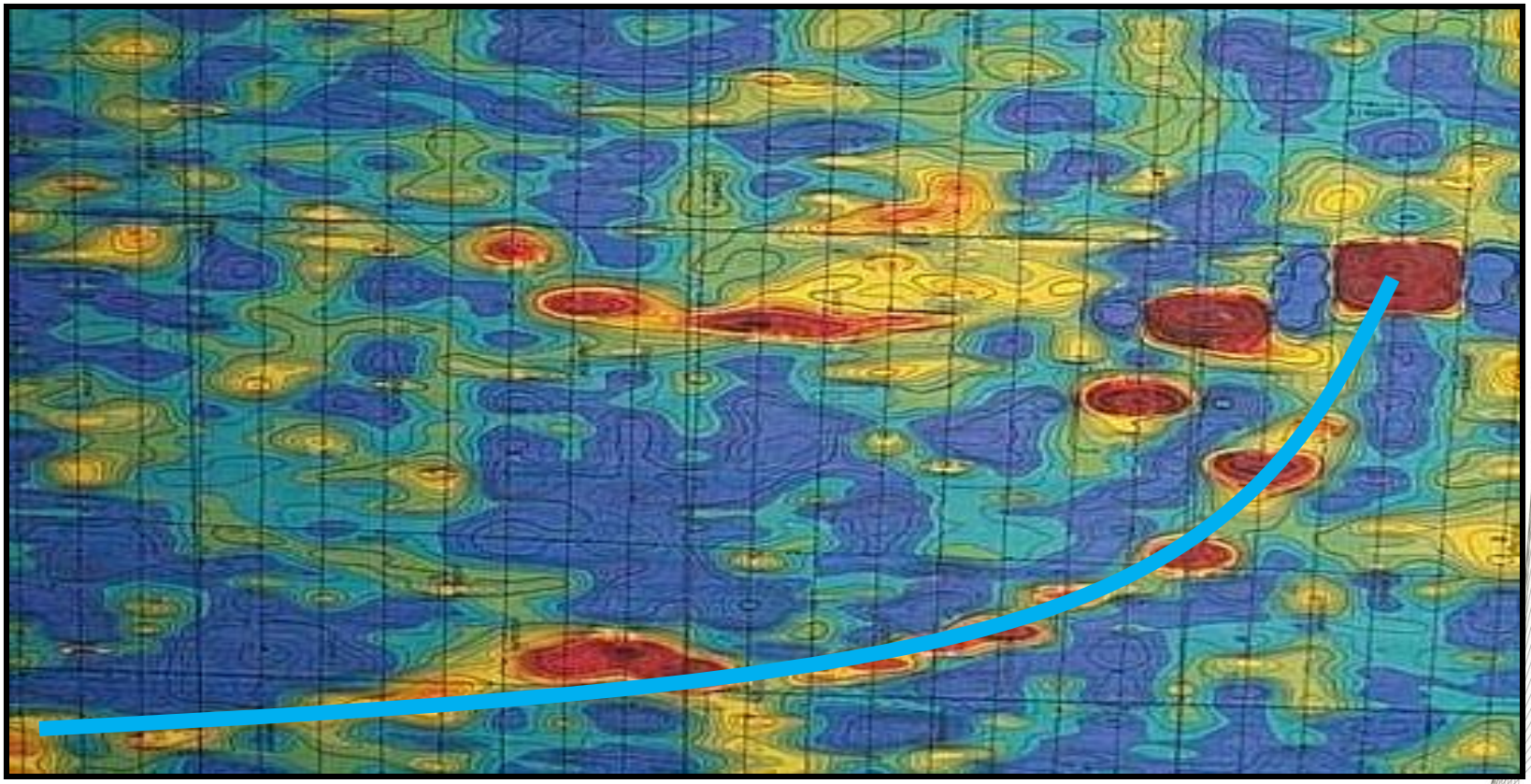


2010

2014

NORM Legacies and environmental contamination

Blue: 0-7 cps (normal)
Broun: 40-2000 cps (radium contamination)



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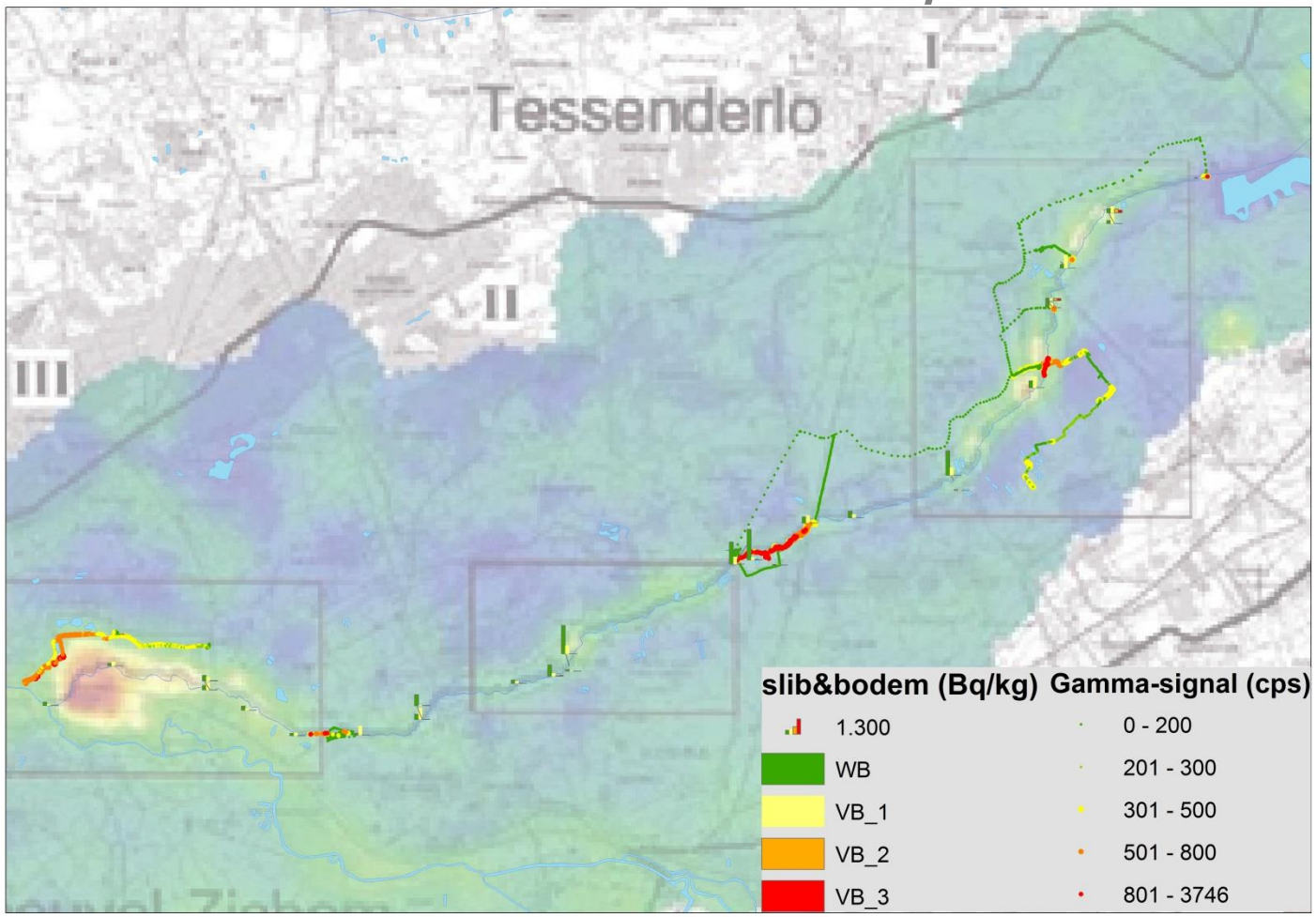
To compare…

Normal background in the campine area: 50-80 nSv/h



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Results-
Soil samples

Left bank

- Average: 1330 Bq/kg
- Range: 8-8600 Bq/kg
- Average riverside: 3800 Bq/kg
- Average border study area: 150 Bq/kg

Right bank

- Average: 810 Bq/kg
- Range: 15-3700 Bq/kg
- Average riverside: 2000 Bq/kg
- Average border study area : 80 Bq/kg

Results-
Radon measurements

Indoor

- Number: 53
- Average: 42 Bq/m³
- Range: 19-134 Bq/m³

Reference Flanders region
40 Bq/m³

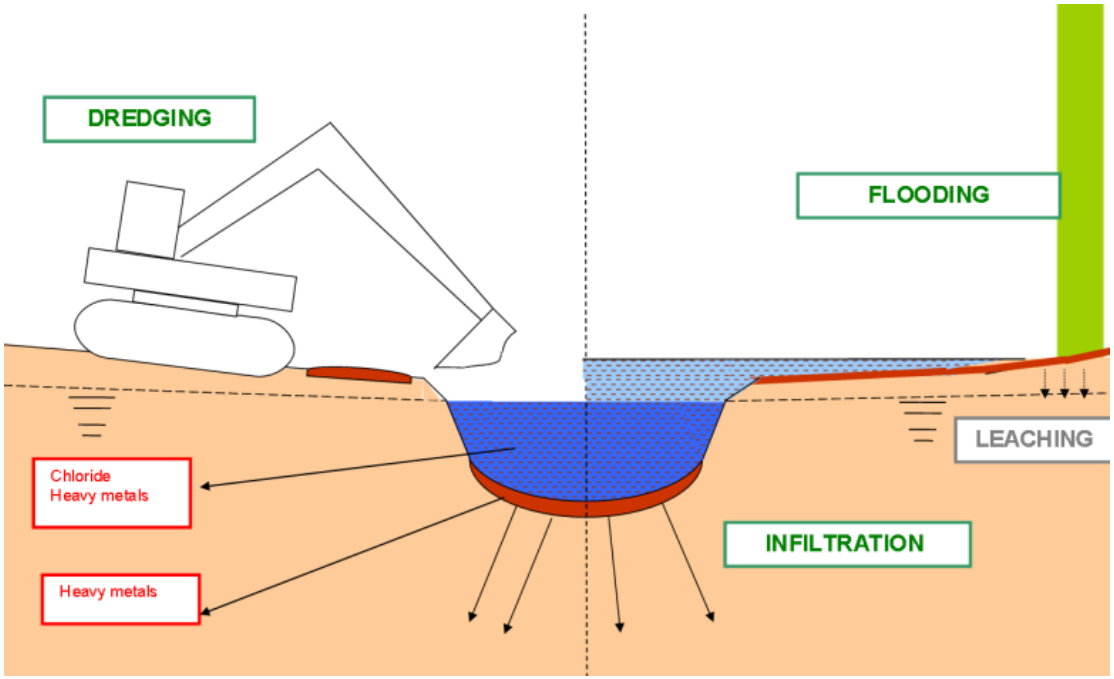
Outdoor

- Number : 3
- Average : 50
- Range: 40-70 Bq/m³

Reference Flanders region
10 Bq/m³

< 20 Bq/m³	20 – 39 Bq/m³	40 – 59 Bq/m³	> 60 Bq/m³
2%	55%	37%	6%

Contamination of bedding, shores and flood zones



Contamination of the Winterbeek over 17 km length, flooding areas of ~721 ha, ~27k m³ sediment and soil

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Conclusions

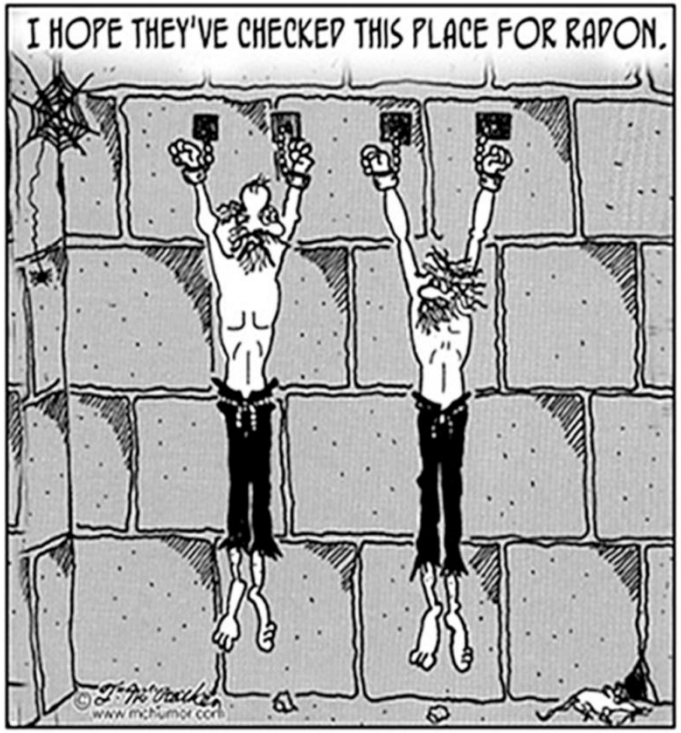
Radon is of concern in the NORM industry for the workers

- Measurements and monitoring

Radon is of concern in the NORM legacy environmental contamination

- Measurement campaigns and remediation

THANK YOU FOR YOUR ATTENTION!



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