UK Health Security Agency

Radon

Tracy Gooding, MSc CPhys MInstP
UKHSA Radiation, Chemical and Environmental Hazards Directorate

Contents

- Radioactive decay
- Health effects
- Levels and variations
- Measurement and control
- Maps

- 1970: The National Radiological Protection Board (NRPB)
- 2005: NRPB was incorporated into the Health Protection Agency (HPA)
- 2013: Public Health England was created and absorbed the HPA
- 2021: United Kingdom Health Security Agency (UKHSA)

Radon

NEWS / HIGHLANDS

Specialists consulted on radon level at Highland school

by Sue Bestan

January 23, 2015, 11:05 am

Work has been carried out to reduce the radon level at Spean Bridge Primary School

Specialists are being consulted about a Highland school after testing revealed high levels of a carcinogenic radioactive gas.

Highland Council today said the levels of radon gas, which can cause lung cancer, recorded at Ardnamurchan High School and hostel in Lochaber were higher than the target for a workplace environment.

And the local authority is now consulting specialist radon contractors to find out whether work needs to be carried out to reduce the readings.

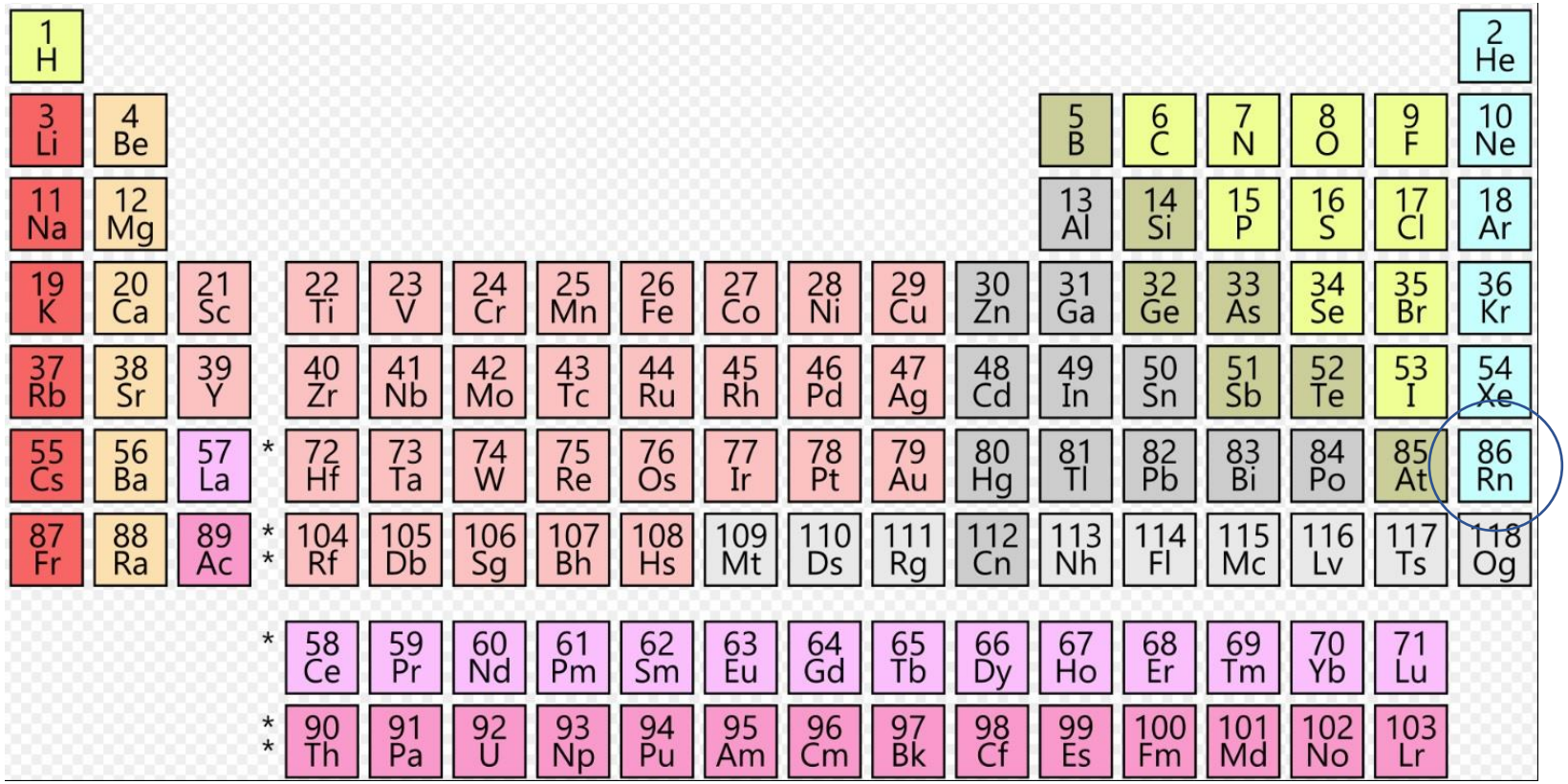
Some minor actions, which have been shown to assist in mitigating against radon, were carried out, including opening 'trickle' vents, checking air extract systems, sealing floor cracks and sealing around pipes.

"The council's aim is to reduce radon levels to as low as is reasonably practical to minimise long-term risks presented by radon."

She added that the local authority had discussed the results with Public Health England and would be consulting its' specialist radon contractors to determine what, if any, further steps were necessary.

- The combination of radiation and children can be emotive
- The response of stakeholders and local media varies considerably around the UK

Radon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91 Pa
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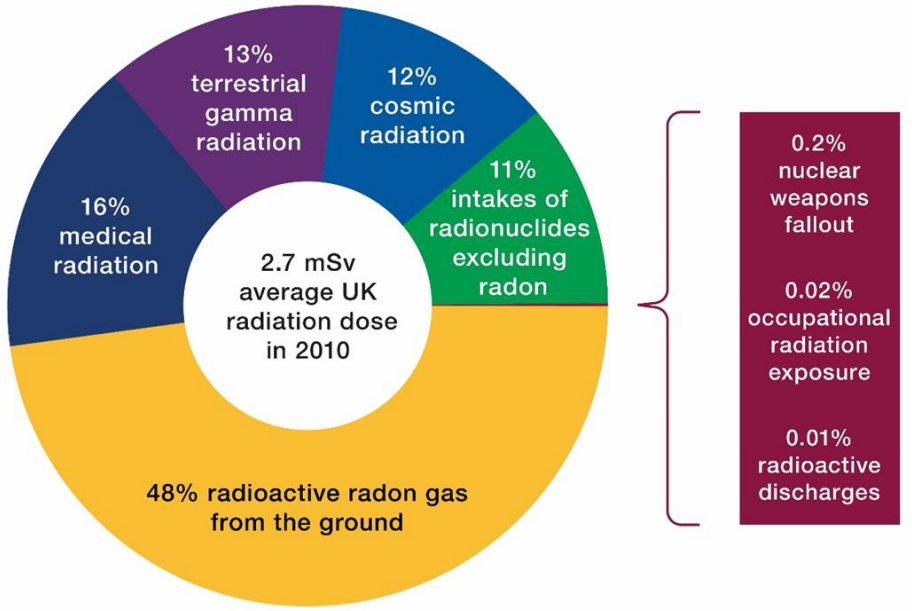
94 Pu
95 Am
96 Cm
97 Bk
98 Cf
99 Es
100 Fm
101 Md
102 No
103 Lr

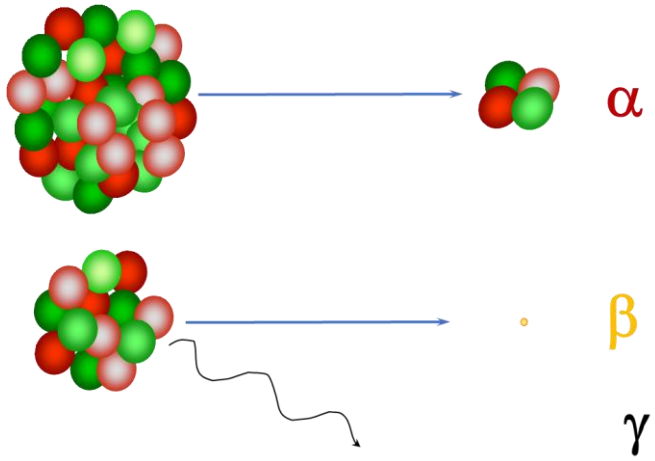
Radon gas

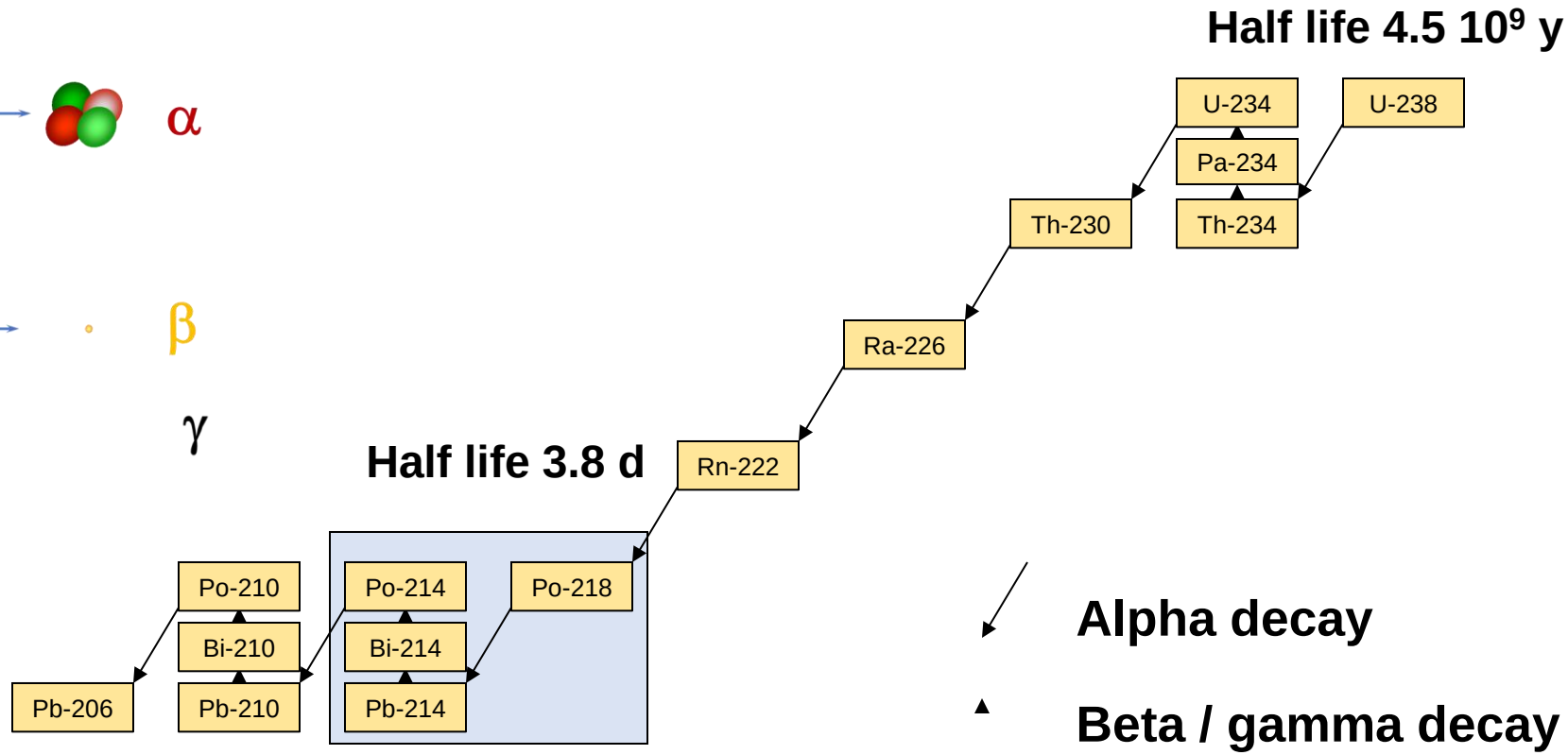
- From natural sources of **uranium** and thorium – few ppm in rock
- Three natural isotopes: **Rn-222**, Rn-220 (‘thoron’), Rn-219 (‘actinon’)
- Noble gas diffuses through ground or porous media
- Mixed in air – does not ‘settle’
- 3.825 day half life, decays to particulates
- Alpha radiation damages lung tissue
- Units of becquerel per cubic metre of air, Bq m^{-3}
- UK average is 20 Bq m^{-3}
- Over 1,100 radon-related deaths in UK each year



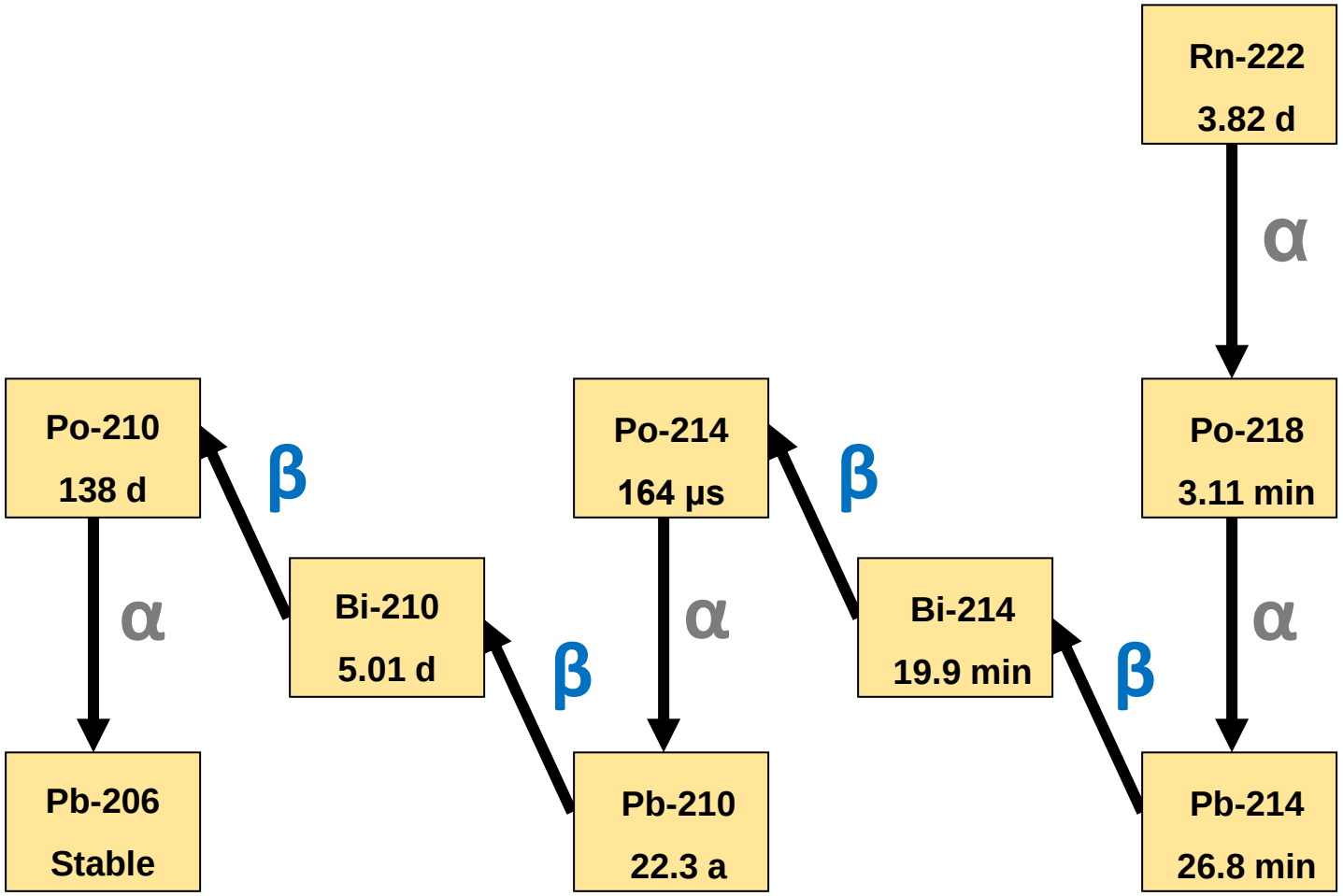
Breakdown of the average UK radiation dose in 2010 by source of exposure

Decay scheme of uranium-238

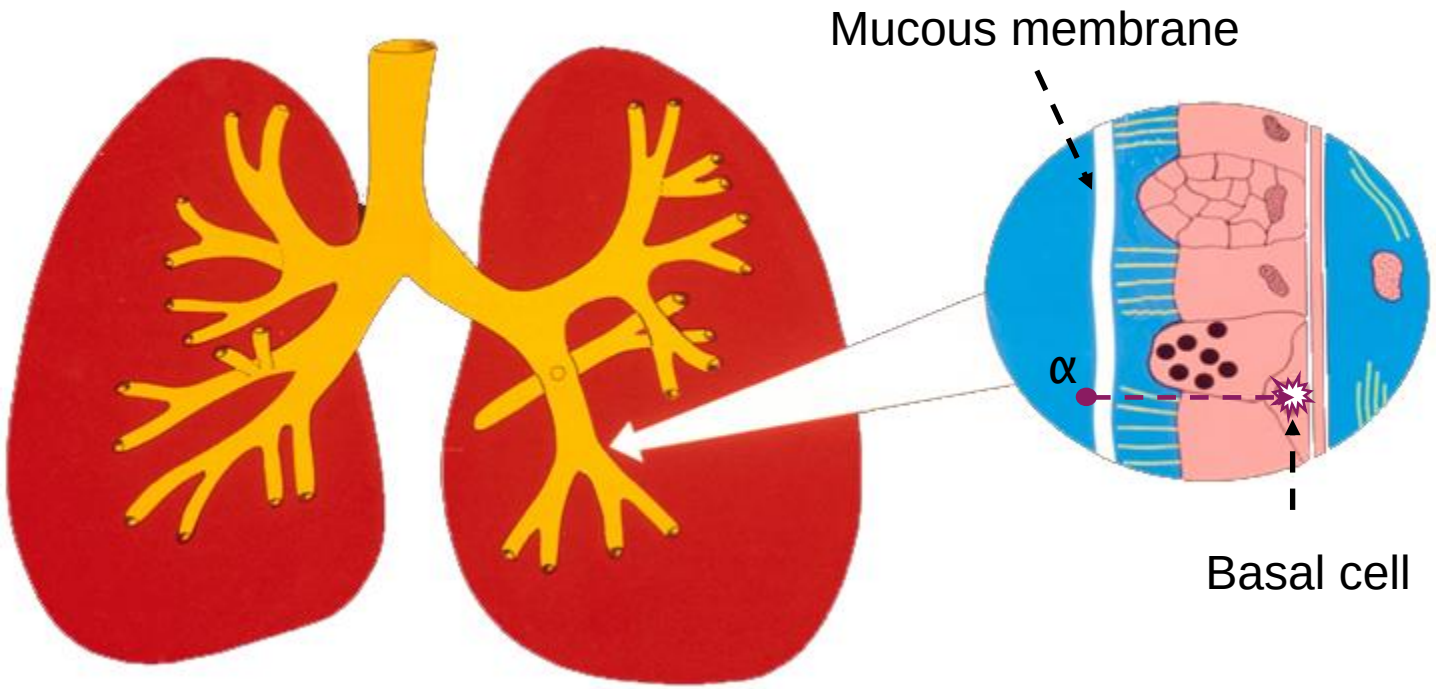


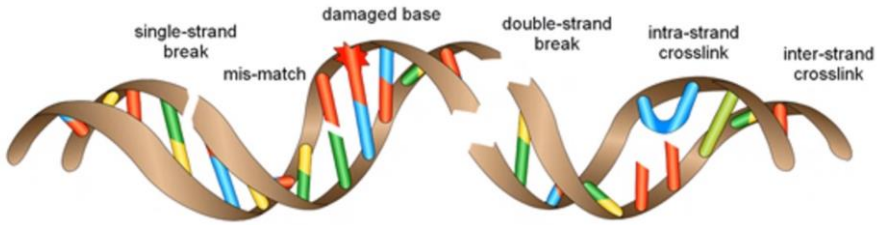


Radon-222 decay scheme



Bronchial epithelium





(Alpha) irradiation leads to increased risk of lung cancer

Radon sources

Ground

- geology
- all rocks and soils contain few ppm uranium

Building materials

- can be main source in low radon areas
- no problem in UK - Sweden, Hungary local problem

Water

- mains water supplies - no problem
- private water supplies - can exceed WHO guidelines

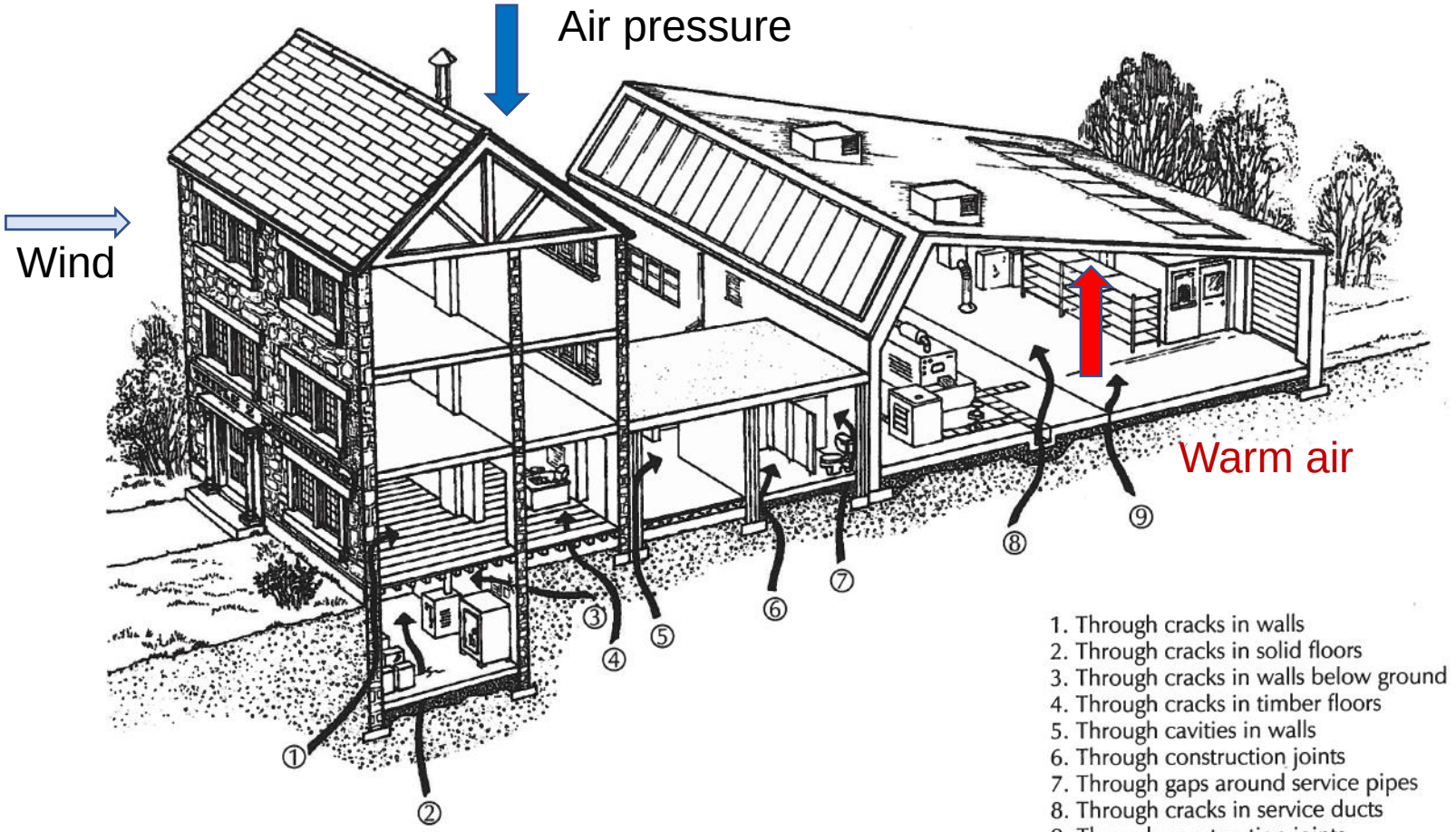
Natural gas

- very low dose

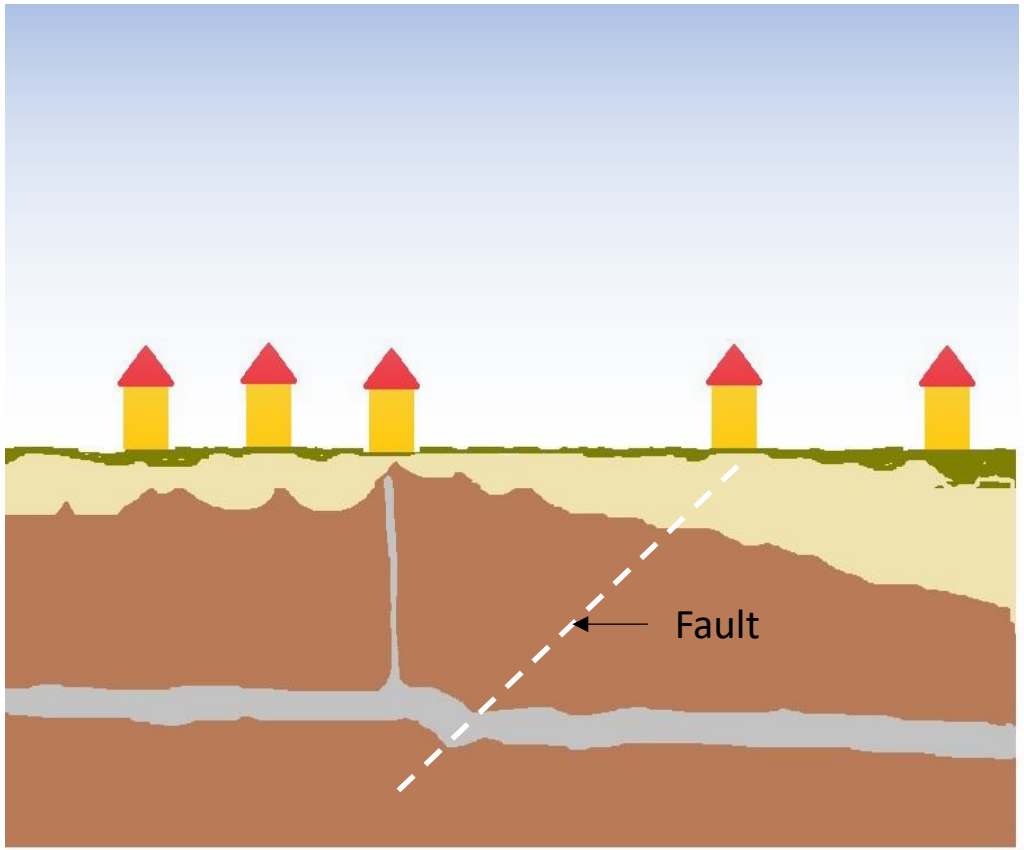
Other items

- geological samples
- luminous watches and instruments

Radon ingress

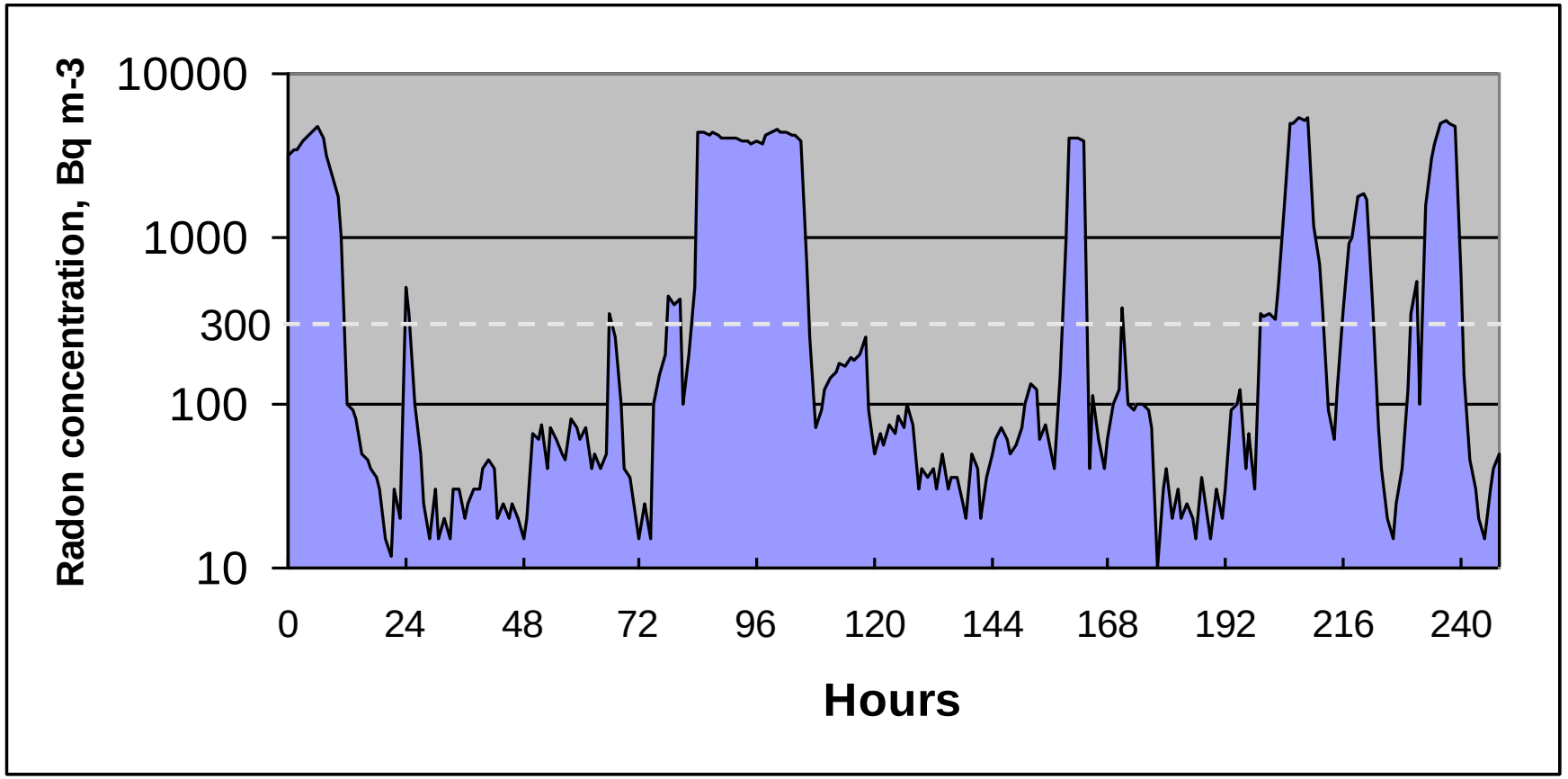


Radon and geology

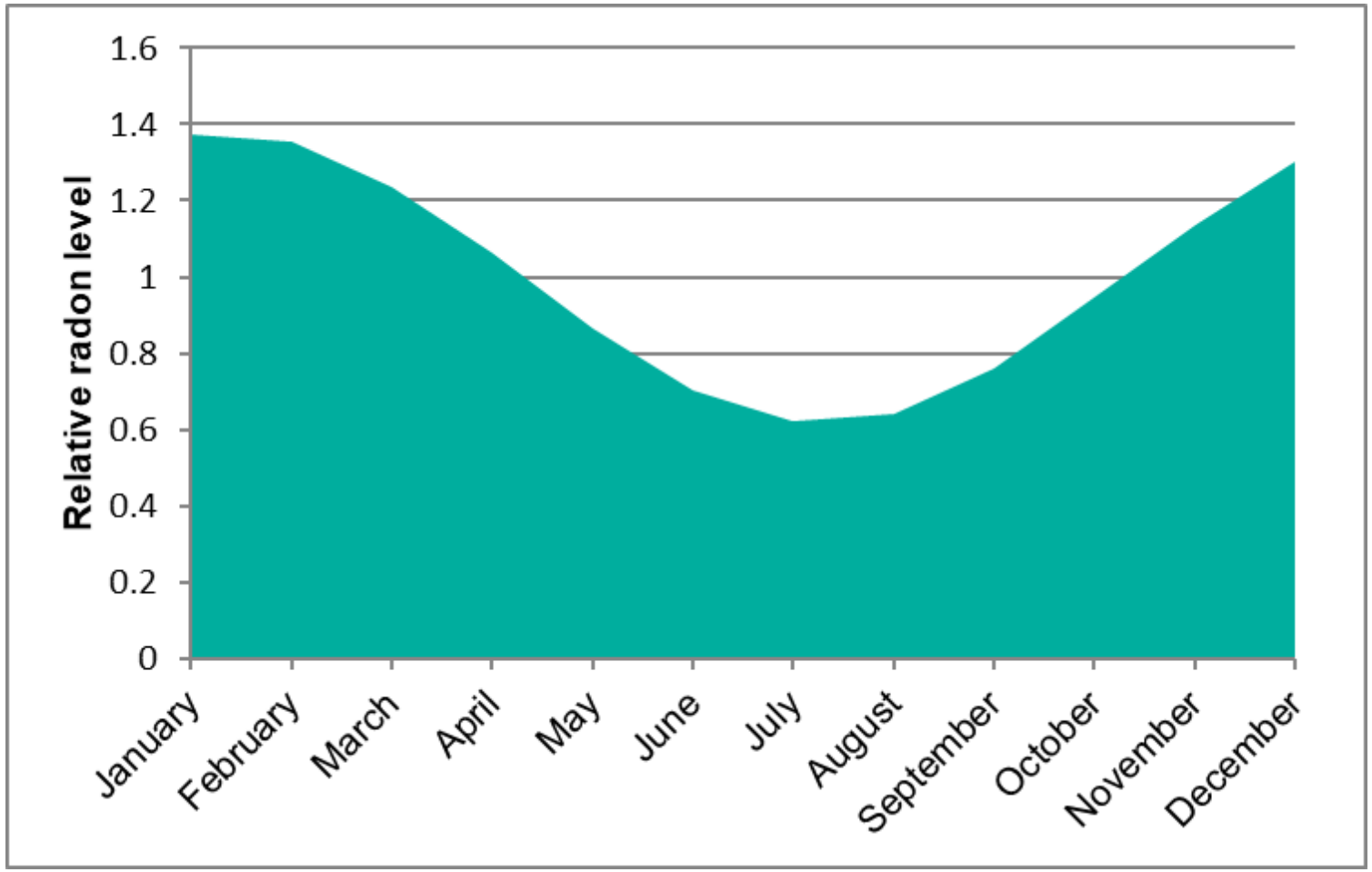


- Natural process
- Geology – rock faults, permeability, gas movement, type of overburden
- Small changes in geology (and differences in heating, ventilation, occupancy, usage and settlement) mean that every building is unique – radon levels sometimes vary by orders of magnitude between neighbours
- We can predict the radon *potential*, but only a measurement will show the radon level

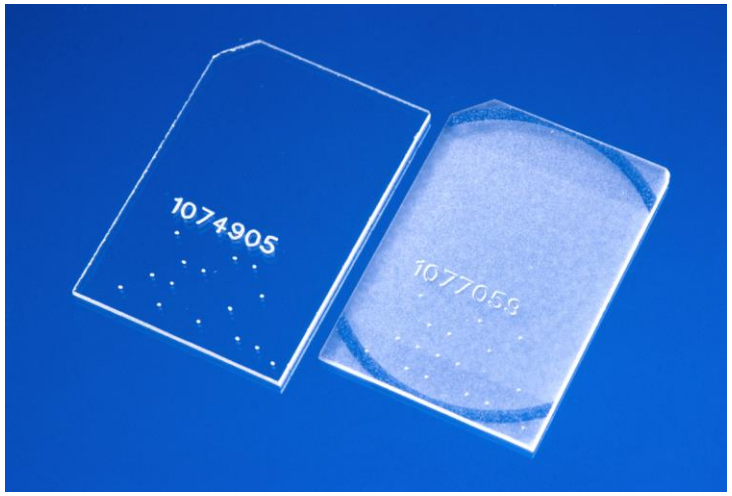
Radon level variation

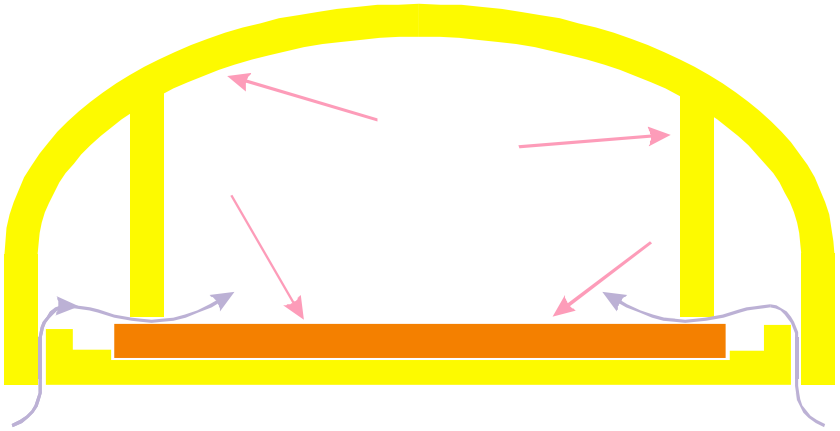


Radon levels vary by season (buildings)



Radon monitors





Control strategy

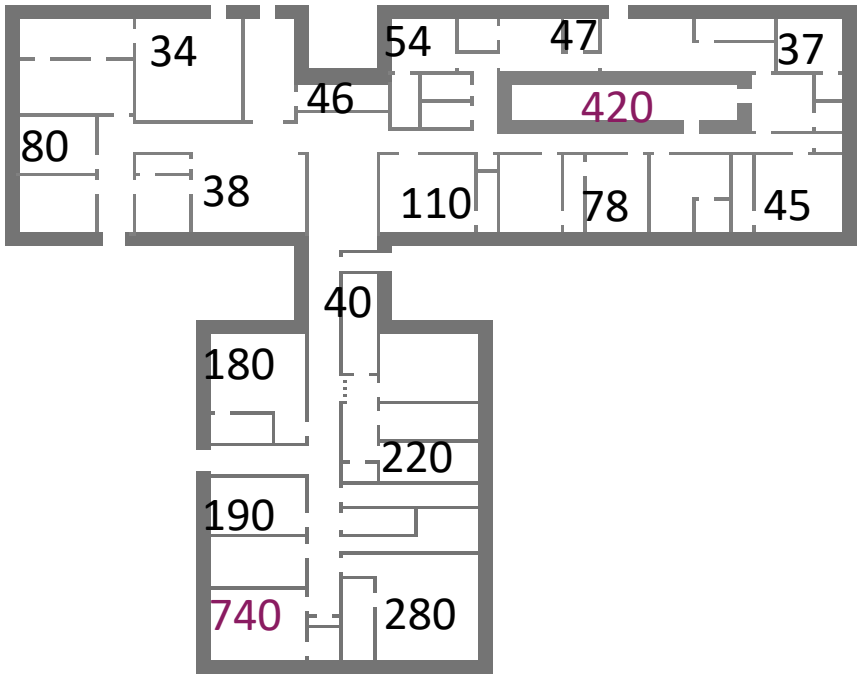
Sector	Domestic	Occupational
Responsibility	Householder	Employer
Control	Voluntary*	Statutory
Government	Encouragement	Enforcement
Action Level (annual average)	**200 Bq m^{-3}***	**300 Bq m^{-3}**
Target Level	**100 Bq m^{-3}**	

*** HHSRS puts duties on landlords (Housing Act 2004)**

Radon in regulations: at work

- **The Management of Health and Safety at Work Regulations 1999**
  - Includes (implicitly) requirement to address radon as workplace risk to health
  - HSE website advises testing in radon affected areas, regularly occupied basements and below ground working areas
- **The Ionising Radiations Regulations 2017**
  - Work with radon above 300 Bq m^{-3} (annual average)
  - Employer must notify HSE and manage exposures

Variation across building



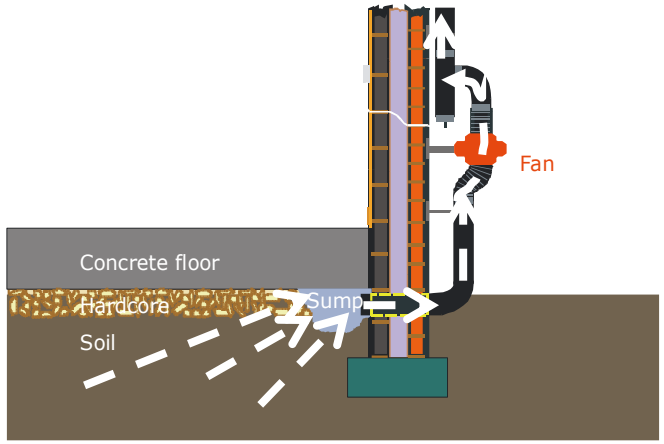
Homes

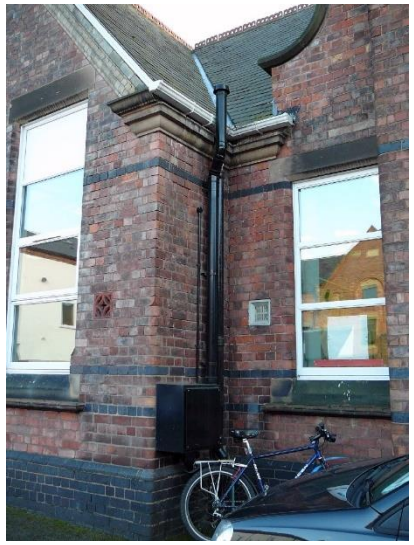
- 1 radon detector in the living room
- 1 radon detector in a bedroom

Workplaces

- Normally use 1 radon detector for every 100 m^2 floor area (10 m x 10 m)
- Open plan workplaces can use few detectors
- Spread evenly throughout building – ground floors and basements
- Focus on occupied rooms
- Unoccupied buildings give uncertain results

Mitigating the problem - sump





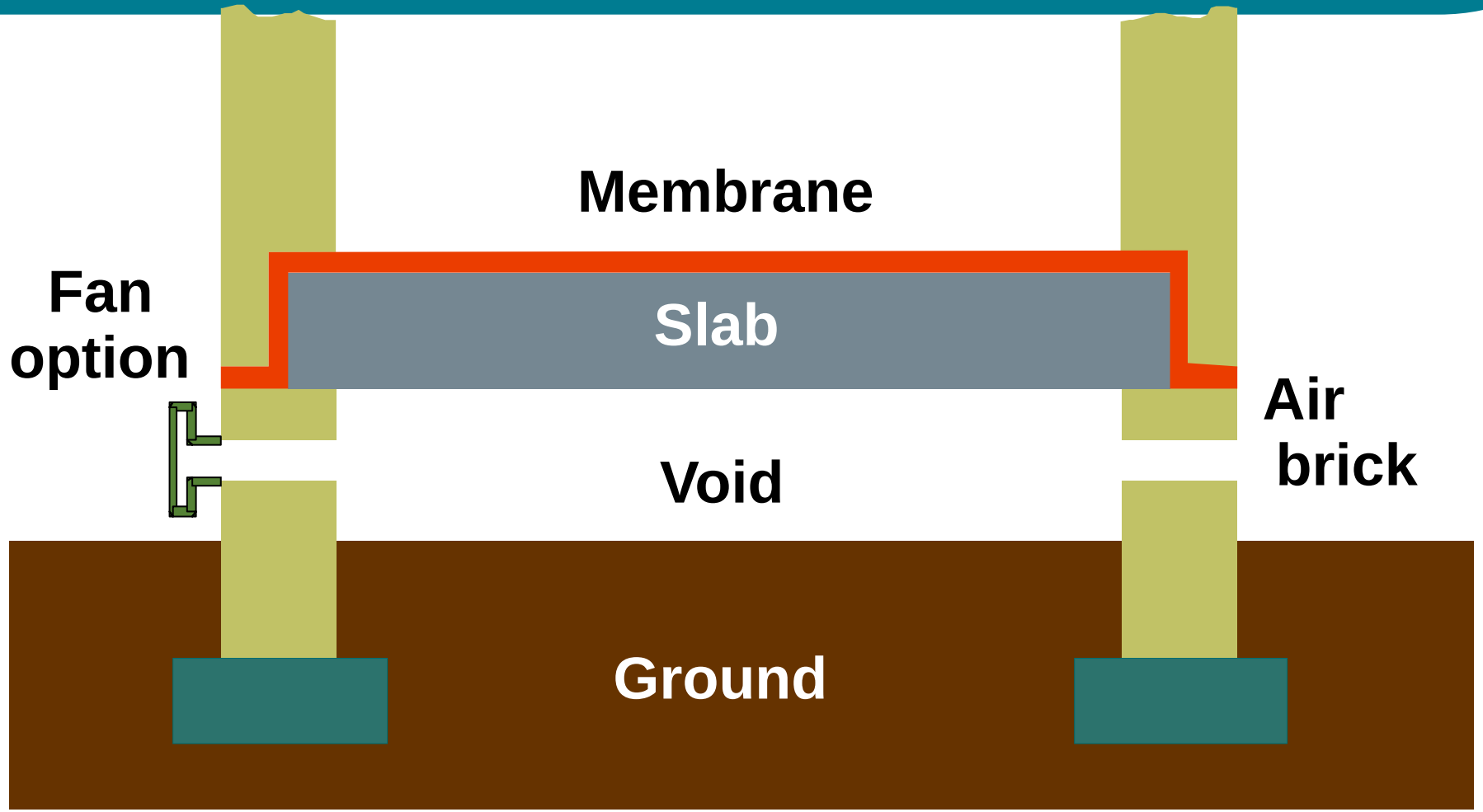
- Work with Cornwall County Council and Building Research Establishment showed that radon levels could be reduced in UK buildings
- Many of the techniques used in homes first tested on council offices and schools
- Cost of systems (£1000-5000)
- Limiting access not usually practical (except basements, cellars, stores, etc)
- RPE to be avoided
- Post-mitigation tests show >75% of workplaces can be reduced below IRR threshold

Mitigating the problem (2)

Sump and pump or underfloor ventilation
Creates a low pressure zone under the floor
Diverts radon-laden air from the room
but - requires permeable ground
- constant fan operation
- often needs floor excavation
Sump and pump is most effective method (often >10x reduction in radon level)

Roof fan
Filtered air is blown in from the loft space to lessen the pressure drop caused by warm air rising
Effective in smaller buildings where modest reduction in radon levels needed or where ground impermeable

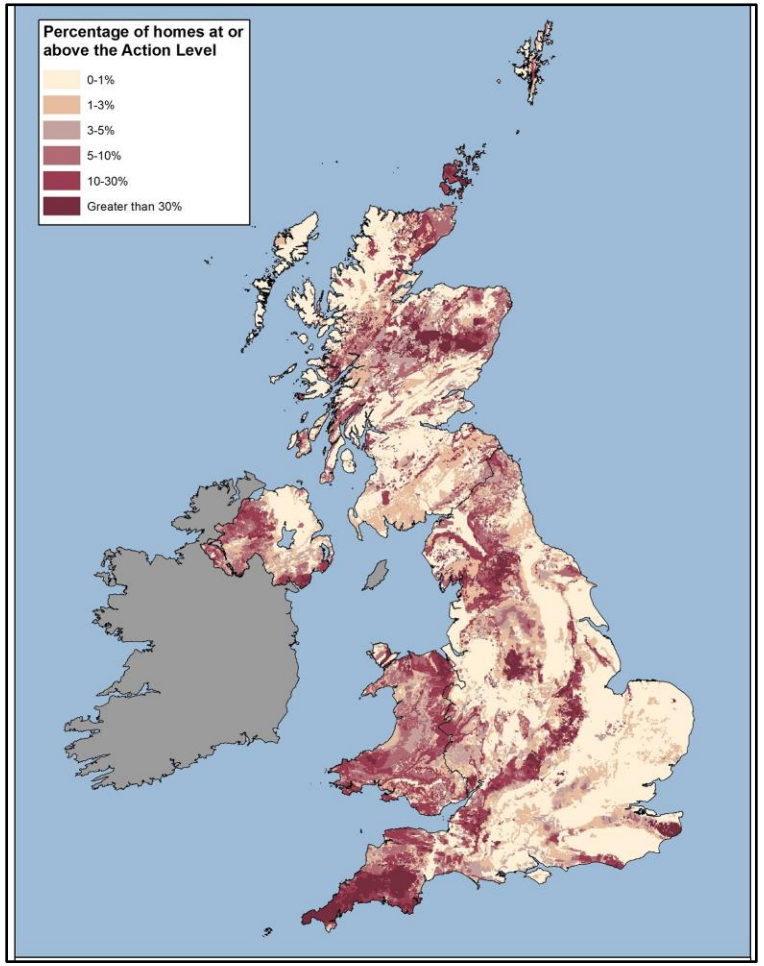
Anti-radon design



New buildings and extensions

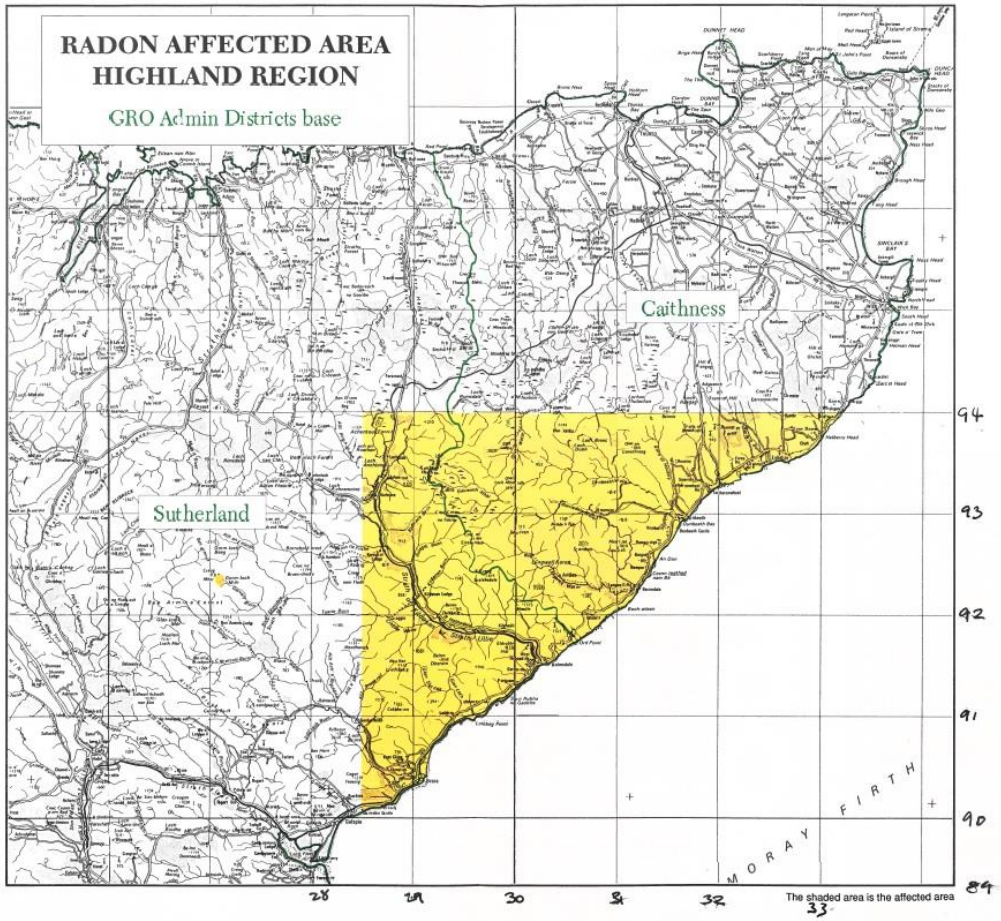
- The Building Research Establishment (BRE) has published Good Building Guides – available from BRE bookshop
- Good Repair Guides (radon sump systems, underfloor ventilation, positive ventilation) available for download from www.ukradon.org
- BR211 provides Guidance on protective measures for new buildings (Building Regulations Part C) https://www.brebookshop.com/details.jsp?id=328065

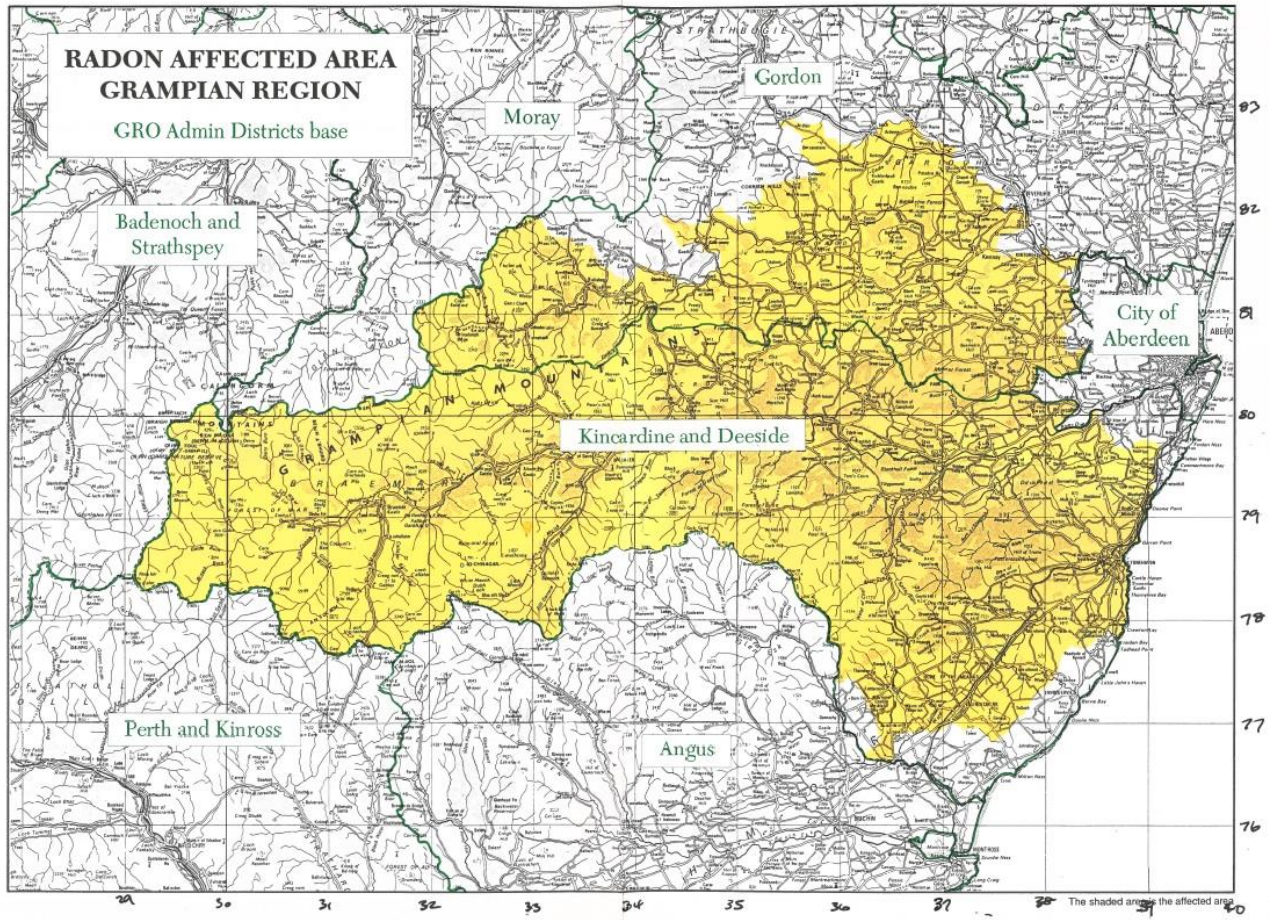
Radon maps and geology



- Mapping radon levels in homes showed the distribution (and variability) with geology link
- The first radon Affected Areas declared in 1990, i.e. where ≥ 1% homes exceed Action Level 200 Bq m^{-3}
- Also used to focus attention on areas where above-ground workplaces most likely to exceed IRR threshold
- Current map derived from geology and measurements in ~600,000 homes
- Basements in all areas should be considered at higher risk
- Maps cannot be used for underground workplaces (mines, caves, etc)

Scotland declared Affected Areas in 1993





Building regulations linked to Affected Areas

Recommendations were made with the first Affected Areas in 1990:

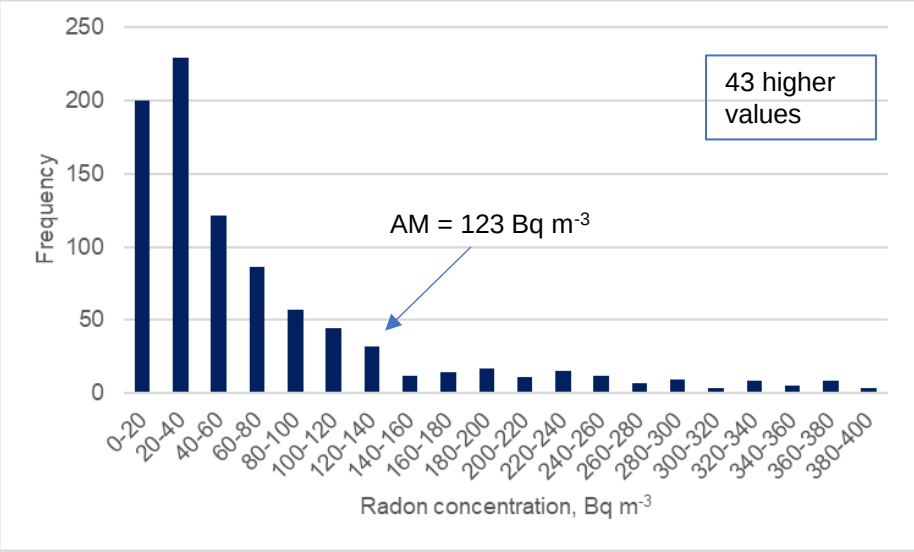
- *Within Affected Areas, localities should be limited for precautions against radon in future homes*
- *Government authorities should decide whether all homes [in Affected Areas] should be constructed with precautions against radon or constructed in the ordinary way, tested for high levels, and remedied if necessary*
- *Homes with precautions against radon should be constructed in accordance with approved guidance issued by the appropriate Government authorities. Compliance with the guidance should offer reasonable assurance that concentrations are as low as reasonably practicable and at least below the Action Level*

The Building Regulations are applied across the UK in 2023 (see BRE Report BR211 (2023) Radon: Protective measures for new buildings):

- Full measures should be installed in new homes and workplaces where at least 10 per cent of homes are expected to exceed the radon Action Level. Basic measures should be installed where the radon potential exceeds 1 per cent (Scotland and Northern Ireland) or 3 per cent (England and Wales).
- Approved Document C - Site preparation and resistance to contaminants and moisture (2004 Edition incorporating 2010 and 2013 amendments) para 2.39-2.40: https://www.planningportal.co.uk/info/200135/approved_documents/65/part_c_-_site_preparation_and_resistance_to_contaminants_and_moisture
- Building standards technical handbook 2022: domestic. https://www.gov.scot/publications/building-standards-technical-handbook-2022-domestic/3-environment/3-2-site-preparation-protection-radon-gas/

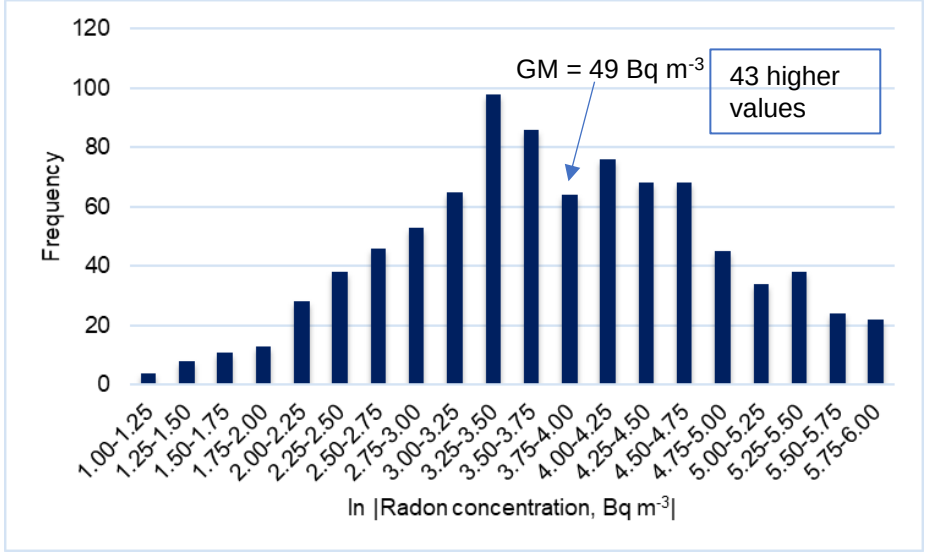
Average concentrations to Affected Areas

- Knowing only the average radon concentration does not tell you whether you are in a radon Affected Area
- To estimate the percentage of houses above the Action Level (200 Bq m^{-3}) requires transformation of the data by taking the log value of each radon concentration
- This produces a bell curve (approximately) where you can calculate the mean and standard deviation… the *geometric mean* (GM) and *geometric standard deviation* (GSD)



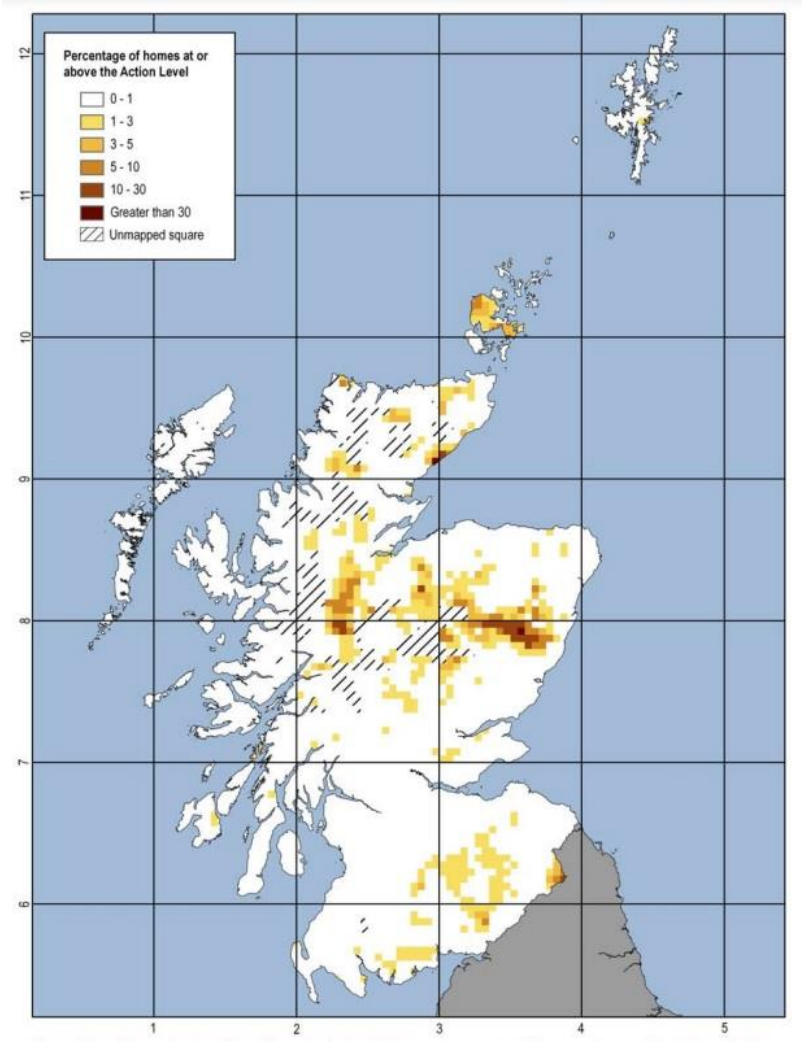
Sample radon data

Same radon data after taking log values



Full map for Scotland following campaign

2008



- Deriving Affected Areas is difficult in regions with low population and few radon measurements
- Ref: BMR Green *et al*. Radon in Dwellings in Scotland: 2008 Review and Atlas. HPA-RPD-051

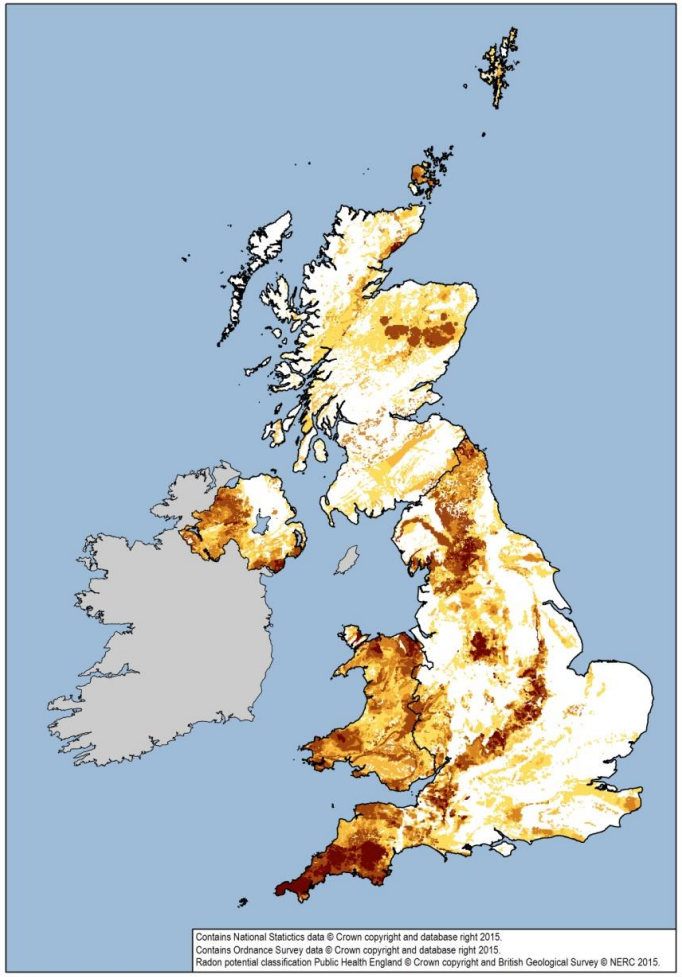
- https://www.gov.uk/government/publications/radon-review-and-atlas-for-scotland

What about geology?

- The main source of radon in the UK is the ground (geology)
- Minor sources include building materials (not a problem in the UK), drinking water (private supplies) and natural gas (methane)
- Changes in geology do not coincide with grid squares…
- A new method was devised that took into account the geological units as well as the radon measurements in homes: joint data set (JDS) mapping
- JDS mapping enables an estimate of the percentage of homes above the Action Level even when there are few or no radon measurements in the grid square, by using the results from measurements on the same geology elsewhere
- JDS mapping also enables maps to be produced at much higher resolution: 25 metres
- However, the resolution means that paper maps cannot show the detail in many areas
- Ref: JCH Miles and JD Appleton. Mapping variation in radon potential both between and within geological units. Journal of Radiological Protection Vol 25 pp 257-76

UK re-mapped using JDS method

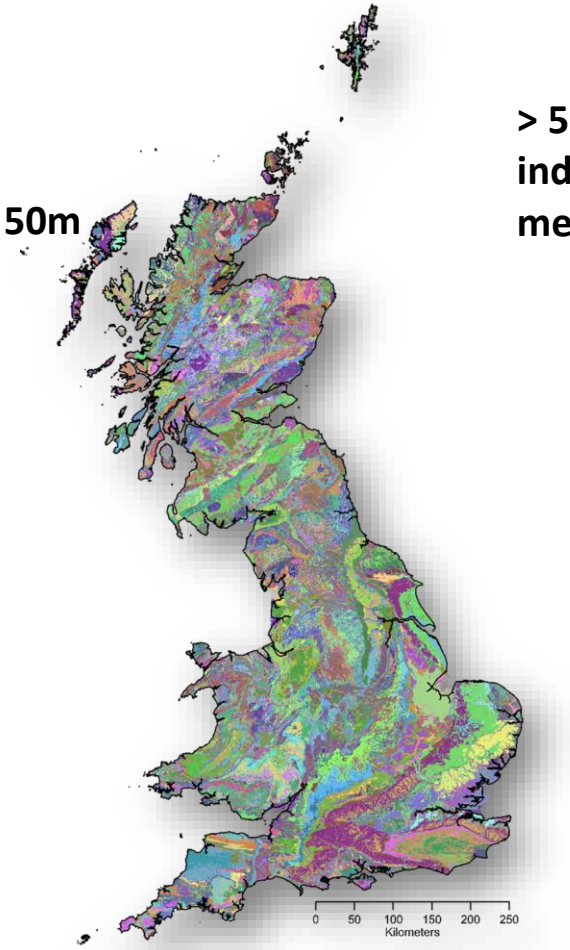
2015



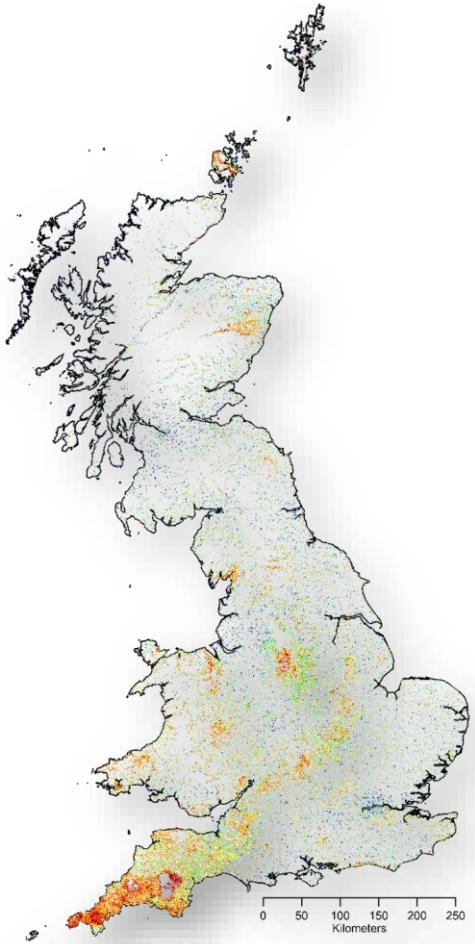
- All the UK radon potential maps were update to the JDS methodology, based on measurements in almost 500,000 homes and the underlying geology
- The *indicative* printed map shows the highest (worst case) radon potential in each 1 km grid square; the 1600 25-metre squares in each 1 km may have a variety of radon potentials
- JCH Miles et al. Indicative Atlas of Radon in England and Wales. HPA-RPD-033 (2007) https://www.gov.uk/government/publications/radon-indicative-atlas-in-england-and-wales
- JCH Miles et al. Indicative Radon Atlas of Radon in Scotland. HPA-CRCE-023 (2011) https://www.gov.uk/government/publications/radon-indicative-atlas-in-scotland
- Z Daraktchieva et al. Radon in Northern Ireland: Indicative Atlas. PHE-CRCE-017 (2015) https://www.gov.uk/government/publications/radon-indicative-atlas-for-northern-ireland

Source + Pathway + Receptor Model

~ 10 000 Rock types mapped to 50m resolution



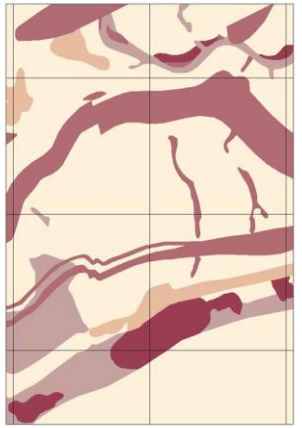
> 560 000 indoor radon measurements



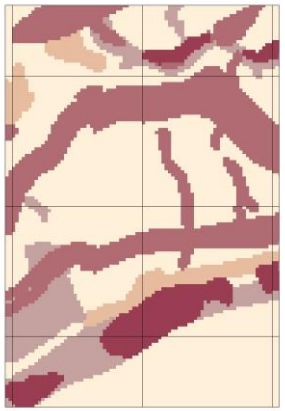
Statistical model to combine source, pathway and receptor

Updated GB map

- Covers England, Wales and Scotland
- Uses 560,000 domestic radon measurement results - all geo-located at premise level
  - 80,000 more radon measurements were added to the data set (UKHSA)
  - Initial results only - repeats or post remedial work tests excluded
- Uses an updated geology
- The statistical method to combine radon results and geology was refined
- Map was processed to allow for building footprint (25m)
- Buffer highest to lowest – the reduction in total buffer applied will decrease some AA's



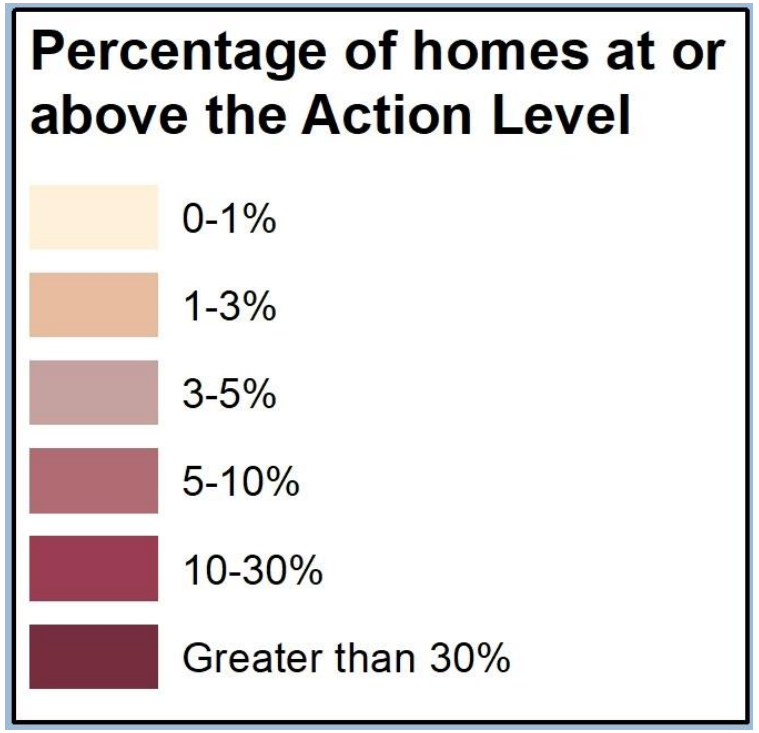
Unbuffered



Buffered

Advice

- Six probability bands – same ranges, revised colours
- All but <1% Affected Areas classed as Radon Affected
- Building Regulations still apply at 10%+ for full and 1%/3% for basic (depending on location)
- All basements/cellars, etc considered at risk of elevated radon levels no matter Affected Area status
- Scotland
  - 2% increase in homes in AA's
  - 1% increase in 1-10% bandings – basic protection range
  - 1% increase in 10-30% bandings – full protection range



Radon summary

- Radon is an established carcinogen – strong synergy with smoking
- Radon levels highly variable by geographical area, across a building, between neighbouring buildings, over short and long timescales
- Maps highlight areas of greatest risk
- Ground (geology) is main source, modified by building construction and use
- Building materials minor source in UK, but cannot be discounted
- Undertake measurements to determine radon levels – assess against action level for homes (200 Bq m^{-3}) or IRR17 (300 Bq m^{-3}) annual average radon concentration
- Can mitigate existing buildings or protect new buildings from radon ingress (BR211)
- UKHSA radon website: www.ukradon.org