CoRWM

Committee on Radioactive Waste Management

Development of a Deep Geological Disposal Facility for Radioactive Waste in the UK

Mark Kirkbride

15th March 2021

Mark Kirkbride

- BEng (Hons) Mining Engineering (Camborne School of Mines)
- MPhil Geomechanics (rock cutting)
- CEng (Chartered Engineer)
- FIMMM (Fellow, Institute of Materials, Minerals and Mining)
- Former British Tunnelling Society committee member

- 28 years practical global experience including:
  - UK coal industry underground engineer 1993 to 2005
  - Ultra-deep shaft sinking & raise-boring specialisms
  - Mine decline and underground infrastructure design & construction
  - Contract production mining
  - Major infrastructure projects; management and contract delivery
  - Tunnel boring machines (TBM), sprayed concrete lining, mechanised & hand tunnelling (hydro, civils & specialist) projects




Introduction

What & Who are CoRWM?

- An Advisory Non-Departmental Public Body
- Scientific Advisory Committee to UK Government(s) on Radioactive Waste Management

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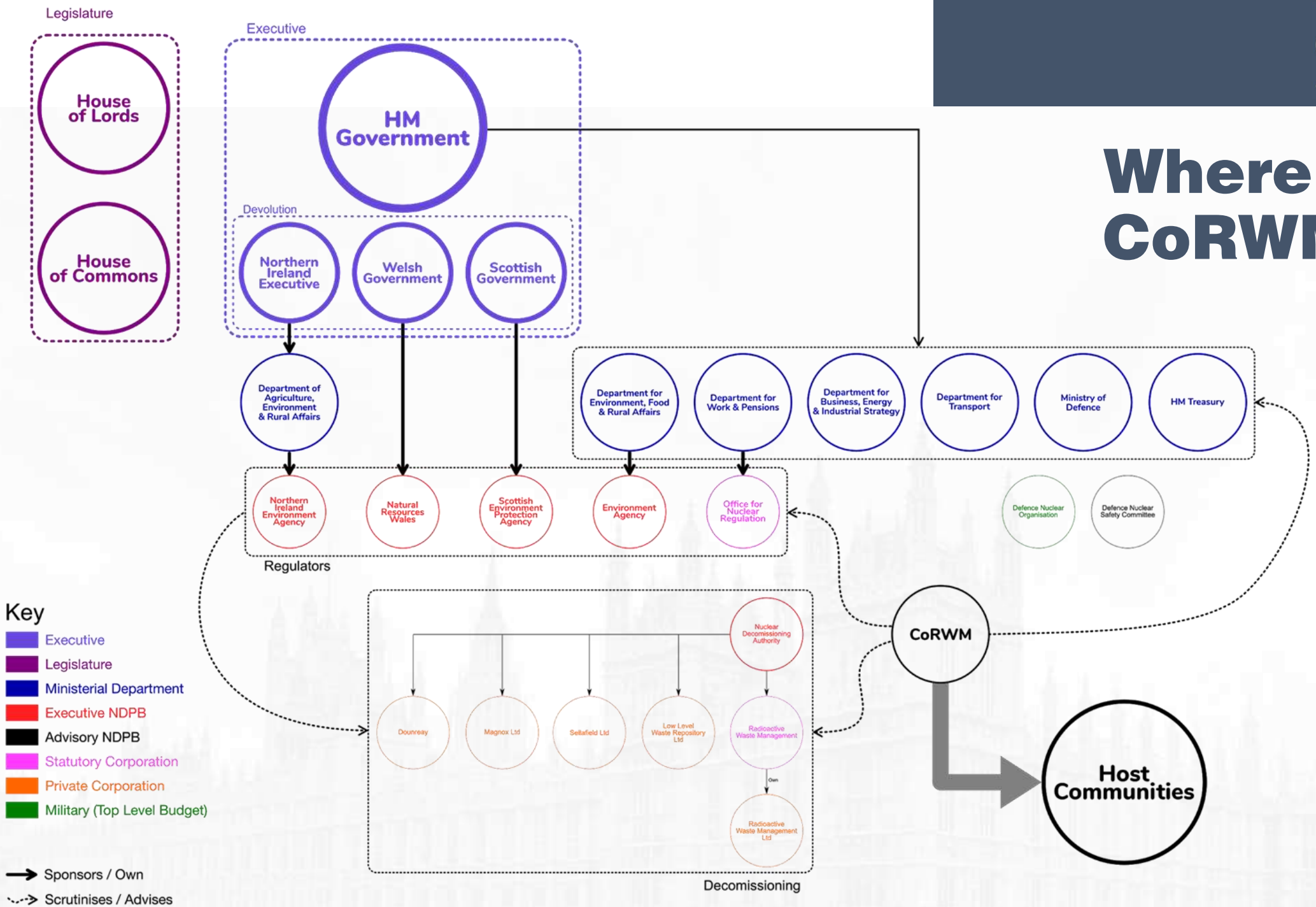
Where CoRWM fits?



What do we do?

Our role is to provide

Independent scrutiny of:

- Government's, NDA's and RWM's proposals, plans and programmes to deliver geological disposal; and
- robust interim storage of the UK's higher activity wastes

Independent advice to:

- Ministers on the management of radioactive waste including the delivery of geological disposal

Inside the breeder removal facility at Dounreay

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CoRWM provides independent scrutiny and transparent advice to the UK government and devolved administrations on the long-term management of higher activity radioactive wastes.

Sir Nigel Thrift (Chair)
human geographer

Stephen Tromans QC
environmental, energy natural resources and planning lawyer

Andrew Walters
environmental lawyer and chartered town planner

Professor Penny Harvey
social anthropologist

Professor Neil Hyatt
nuclear materials chemist

Dr Ray Kemp
consultant on risk management and communication for environmental issues

Mark Kirkbride
mining engineer, underground construction and project delivery

Derek Lacey
nuclear safety, security and safeguards

Professor Gerry Thomas
molecular pathologist

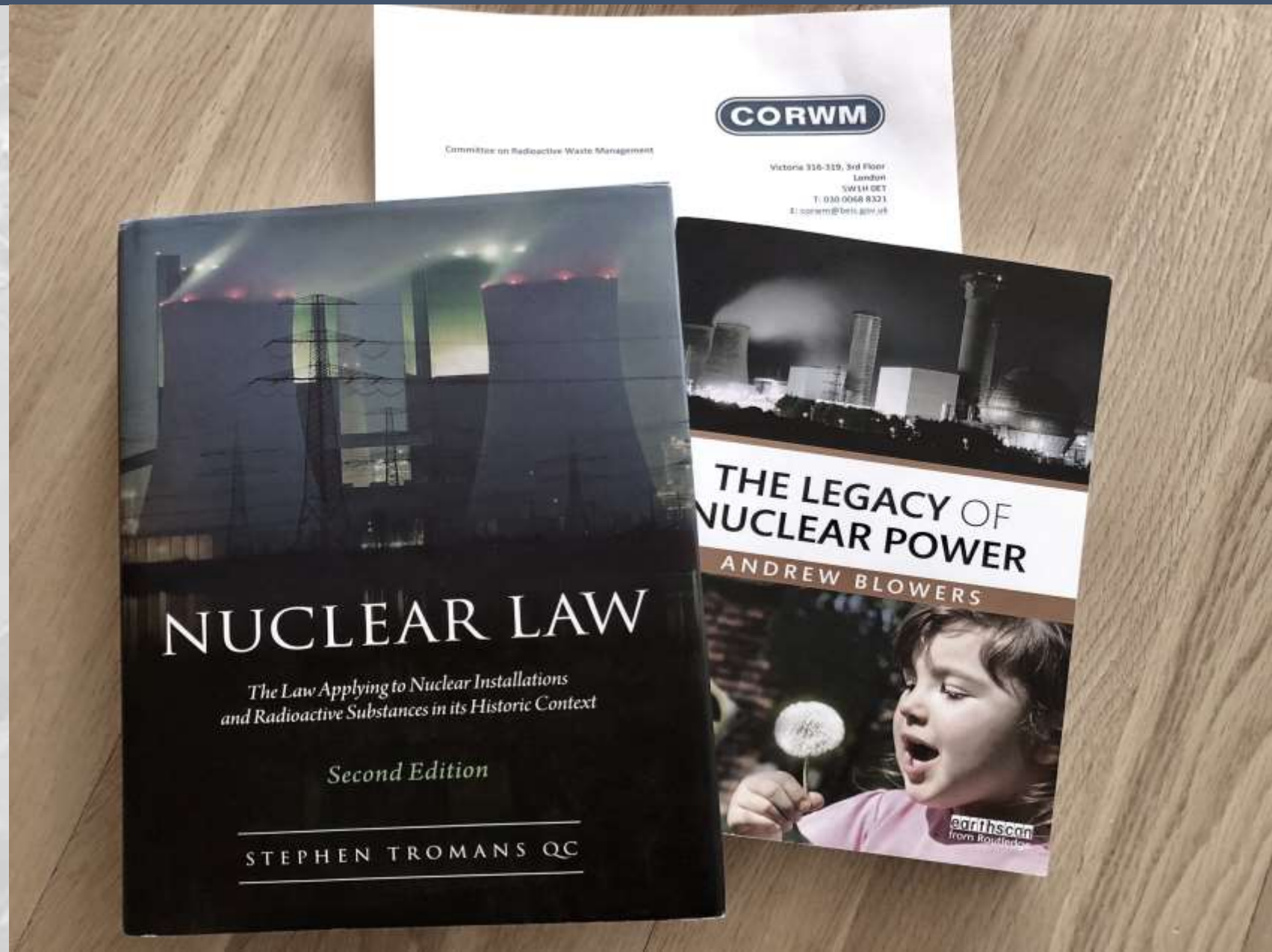
Dr Claire Corkhill
radioactive material corrosion scientist

Dr Richard Shaw
exploration and mining geologist

Professor Campbell Gemmell
environmental policy and regulation

Wide Ranging Capabilities

- Ethics
- Participation
- Expertise
- Knowledge
- Deliberation
- Democratic
- Consultative
- Integration
- Implementation
- Interdependence
- Trustworthiness



UK Site Visits

CoRWM regularly visit UK nuclear sites to observe waste management practices across all stages of the nuclear cycle to inform our advice.

Decommissioning
(Sellafield)

Planned waste management
at new reactors
(Hinkley Point C)

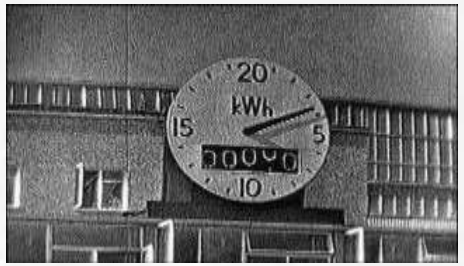
Waste management at
operating reactors
(Sizewell B)

Research relevant to
waste management
(Dalton Cumbrian Facility)

Background and History

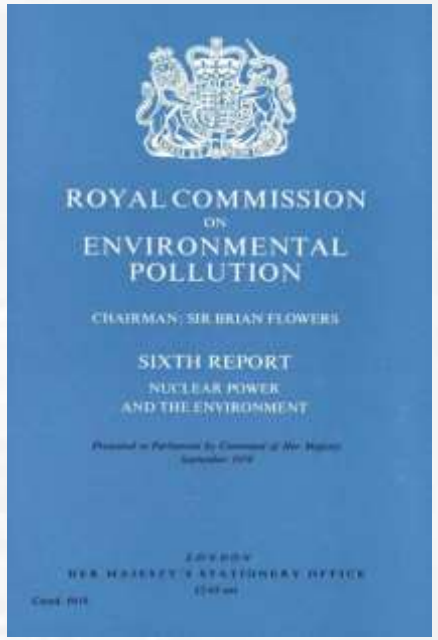
UK Nuclear History

- UK has been a “nuclear nation” since the late 1940s
- In 1947, the Sellafield site opened with a single mission – the production of plutonium, a radioactive chemical element for use in Britain’s nuclear deterrent
- World’s first commercial nuclear power station (Calder Hall) opened in 1956
- Calder Hall station was replicated, creating a fleet of 24 nuclear reactors across the country
- Subsequent phases of new-build, including Magnox (26x)
- Waste management, life-cycle and cleaning up sites were not priorities



History of Higher Activity Waste Management

- 1976 Flowers report
- 1978 UKAEA high level waste studies (first planning applications submitted)
- 1983 Moratorium on sea dumping
- 1983 Nirex established
    - Considered disused mine ICI Billingham 1983
    - Four shallow sites considered in 1986
- 1997 Sellafield Rock Characterisation Facility decision



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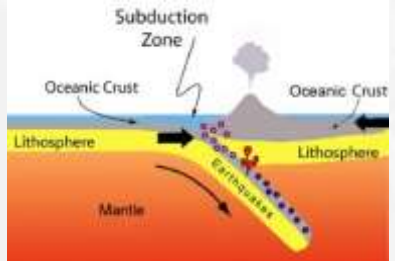
Considers geological disposal to be the best available approach for the long-term management of intermediate and higher activity radioactive waste.

- Wide-ranging programme of public and stakeholder engagement
- 2006 key recommendations to UK governments
- Support public and stakeholder confidence
- Burial underground (200 – 1000 m) in a purpose-built facility concluded to be the best approach
- Alternatives carefully considered; continue review options

Glacier disposal

Disposal in space



Subduction zone disposal

Geological disposal

CoRWM Supports the Working With Communities (WWC) policy
Continues to offer independent advice & scrutiny on implementation

- Influential in developing the WWC policy, e.g. in Parliamentary scrutiny of the National Policy Statement for Geological Disposal
- Recognise challenges will arise during implementation of the WWC policy
- Ready to scrutinise Government response
- Offer independent advice to stakeholders
- Position papers provide published views on specific topics
- e.g. Deep borehole disposal, Retrievability, Regulation (coming soon) and nearshore disposal (coming soon)
- Document archive of >1500 CoRWM documents available

(Stephen Tromans QC gives evidence on behalf of CoRWM at Parliamentary Committee hearing on NPS)

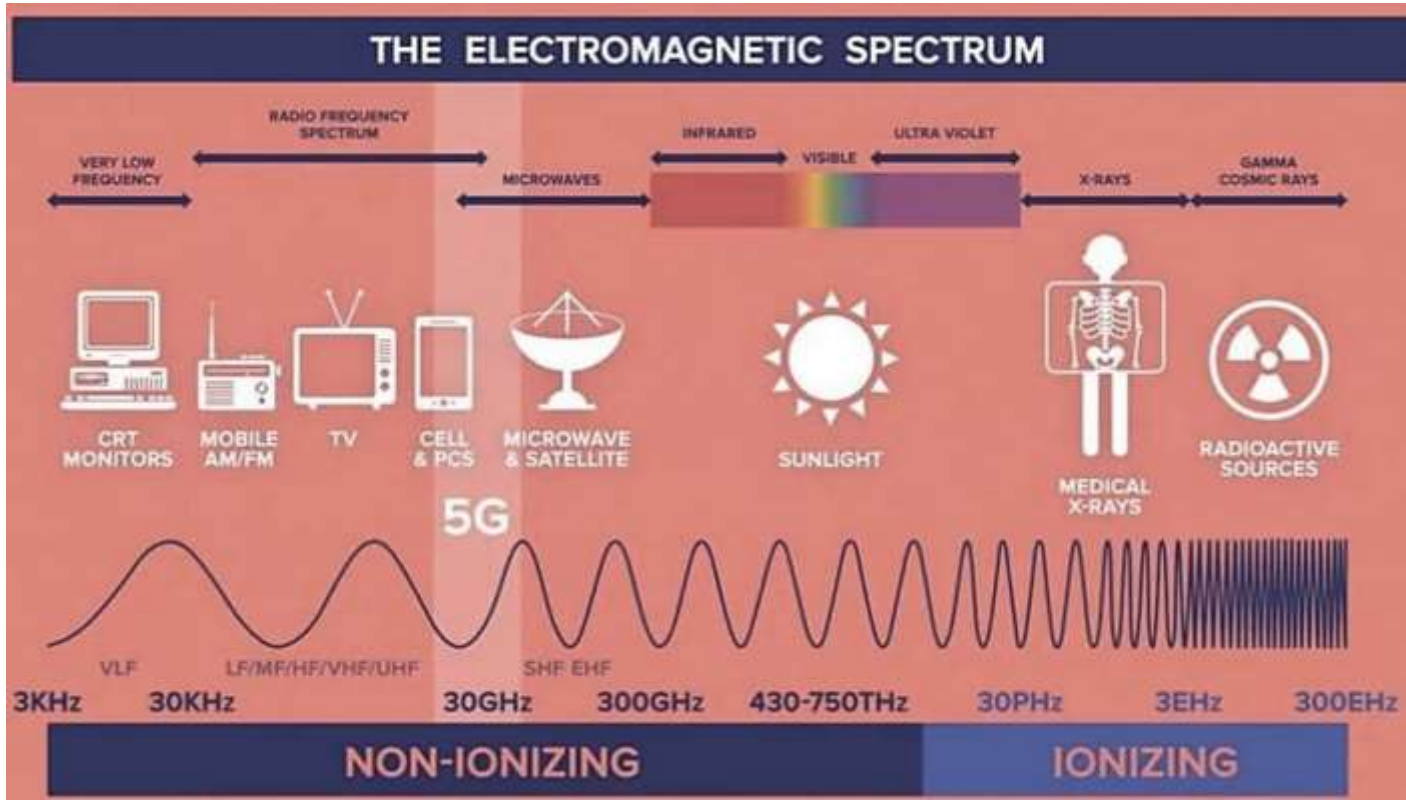
CoRWM Recommended need for robust programme of interim storage & commitment to safe and secure management of wastes

- Continued dialogue with Nuclear Decommissioning Authority on issues related to transport, treatment and conditioning of waste, packaging, storage
- Scrutiny of NDA strategy e.g. integrated waste management and near-surface disposal
- Discussion about “nuclear materials” not currently classified as waste, e.g. plutonium, spent nuclear fuel, uranics
- Discussion about site decommissioning and “end-state”
- Discussion about security and regulation of radioactive wastes

Radiation & Radioactivity

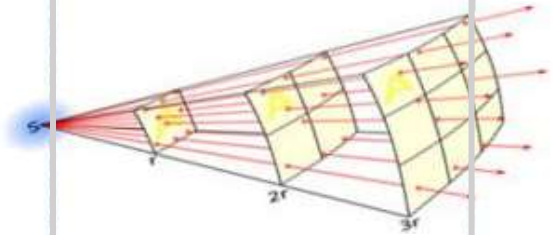
What is Radiation?

- Radiation is a form of energy
- It is emitted by either the nucleus of an atom or an orbital electron
- It is released in the form of electromagnetic waves or particles
- Larger atoms tend to have more neutrons than protons
- This makes them unstable & they may break up releasing Alpha, Beta or Gamma rays
- This process is Radioactivity



Issues with radiation….

- Long history of being made to fear radiation (from atomic weapons)
- General acceptance of medical radiation exposure, and exposure to natural radiation (e.g. Spas) believed to be beneficial
- Relationship between dose and response to all toxins (including radiation)
- Individual dose from radiation in the environment depends on many factors
- Perception that individual dose from nuclear accidents is much higher than it is

Radioactive Decay	Ionizing Radiation	Detection
		
Measurement quantity • Becquerel (Bq) The becquerel is the SI unit of activity 1bq = 1 decay per second	**Transmission factors** • Distance (inverse square law) • Scattering • Absorption Ionizing radiation strength from a point source decreases with the square of distance it travels. The intervening medium can also absorb and scatter radiation.	**Measurement quantities** **Dose** • Gray (Gy) • Sievert (Sv) **Particle counts** • Per second (cps) • Per minute (cpm) Both dose and counts are used: depending on the application and the radiation type. Physical dose is measured in grays, and biological dose in sieverts.

Relative radiation doses

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Source of Exposure	Dose
Dental X-ray	0.005mSv
135g of Brazil Nuts	0.005mSv
Chest X-ray	0.02mSv
Transatlantic flight	0.07mSv
Nuclear Power station worker, average annual dose	0.18mSv
UK average annual radon dose	1.3mSv
CT scan of the head	1.4mSv
UK average annual dose	2.7 mSv
CT scan of the chest	6.6 mSv
Whole body CT scan	10 mSv
Annual limit for nuclear radiation workers	20mSv
Level at which increased cancer incidence seen	100mSv
Single dose to cause temporary radiation sickness	1,000mSv
Lethal Dose to 50% (LD50 within a month of exposure)	5,000mSv

Equivalent dose (measured in millisieverts (mSv)) is the dose exposed over the time period of exposure

http://www.hpa.org.uk/Topics/Radiation/UnderstandingRadiation/UnderstandingRadiationTopics/DoseComparisonsForIonisingRadiation/

What is the UK Situation?

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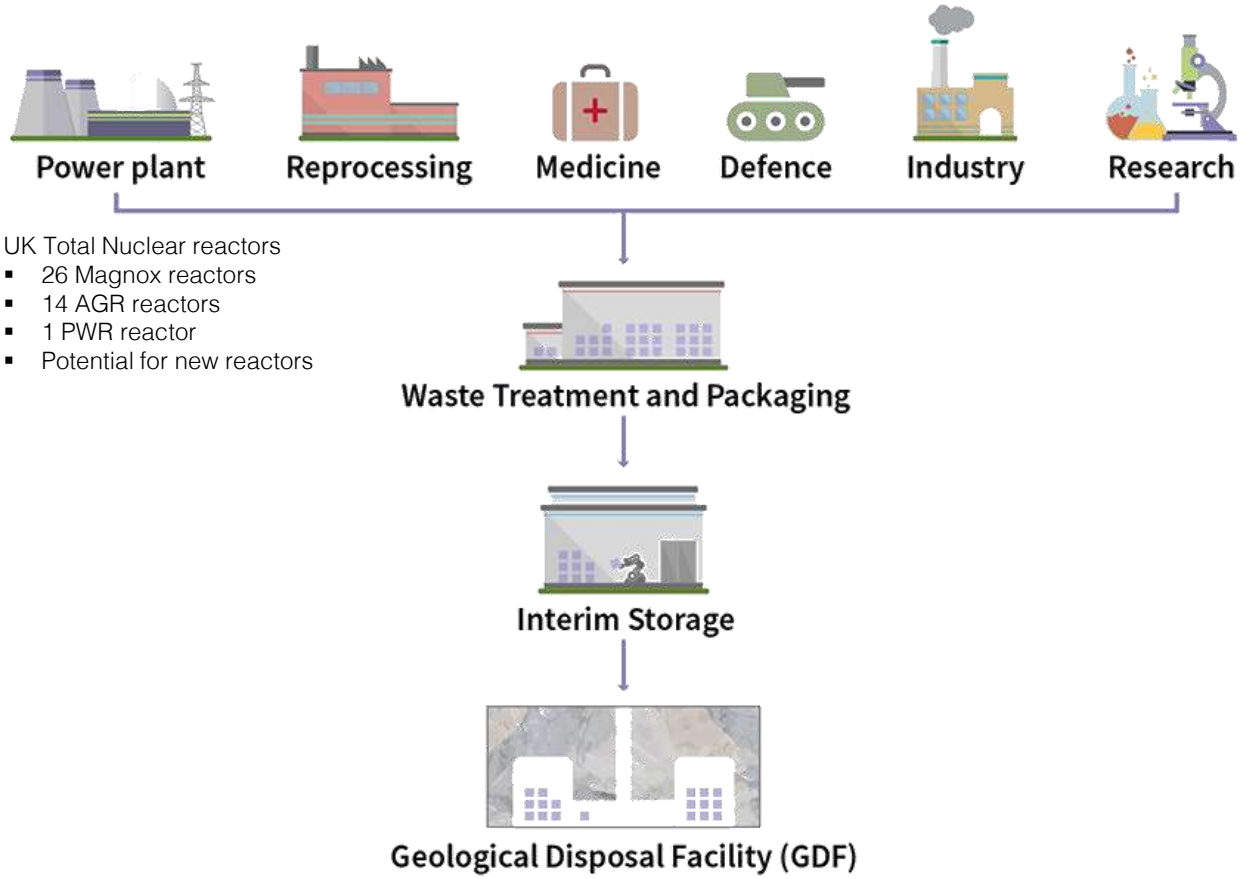
Where is radioactive waste generated?



UK Total Nuclear reactors
- 26 Magnox reactors
- 14 AGR reactors
- 1 PWR reactor
- Potential for new reactors

Sellafield

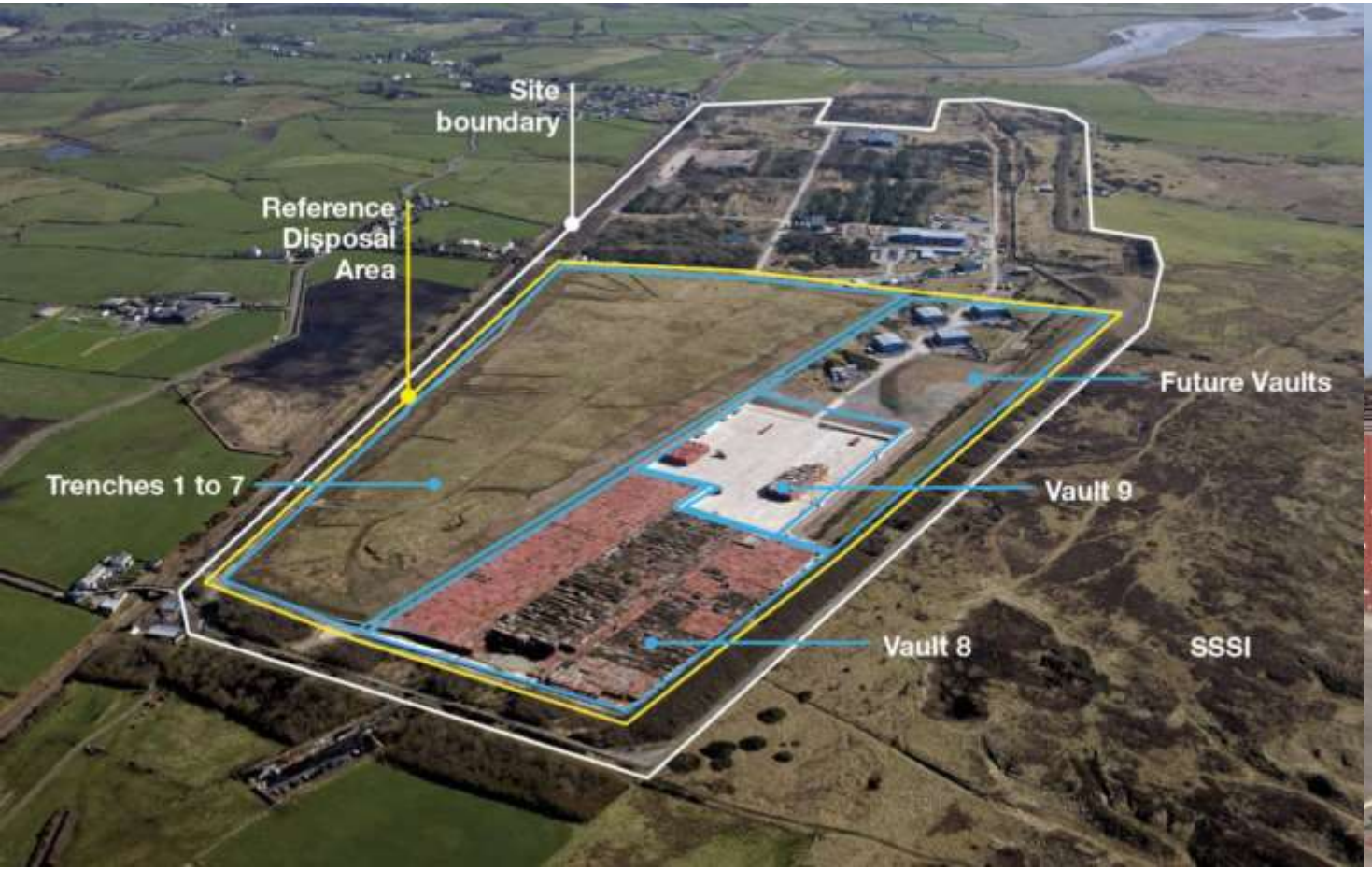
- Home to 4 of the biggest nuclear risks and hazards in Europe
- Over 10,000 staff operate the site
- more than 4,000 supply chain roles
- Annual spend ~£2 billion
- Covers 2-square miles
- Operates 24-hours a day, 7 days a week, 365 days a year
- A non-profit organisation within the Nuclear Decommissioning Authority (NDA)
- Has its own civilian guard force

Above ground storage of ILW

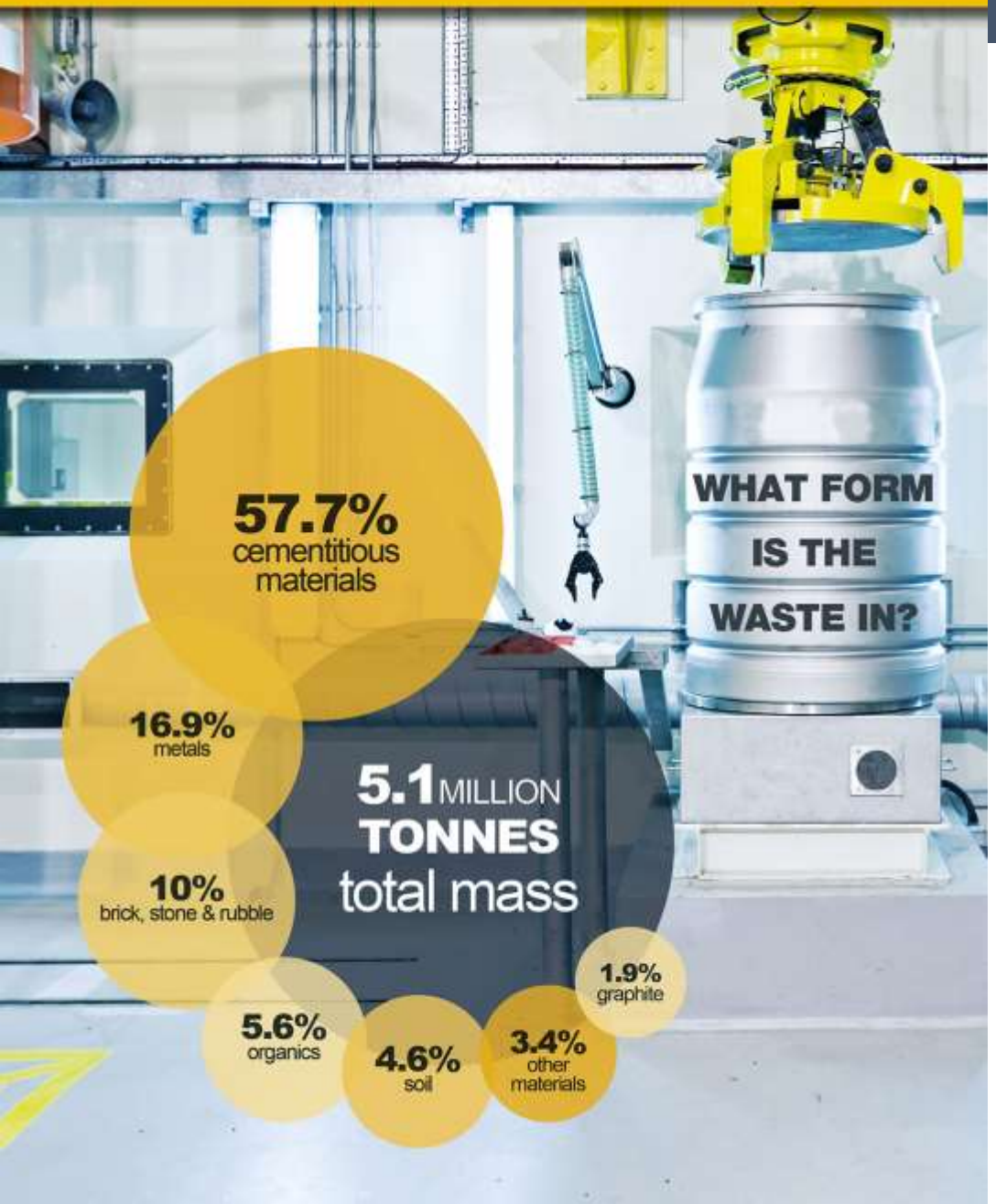
Sellafield Encapsulated Product Store 3

Trawsfynydd storage facility

Drigg – UK LLW Repository



2019 UK Radioactive Waste Inventory



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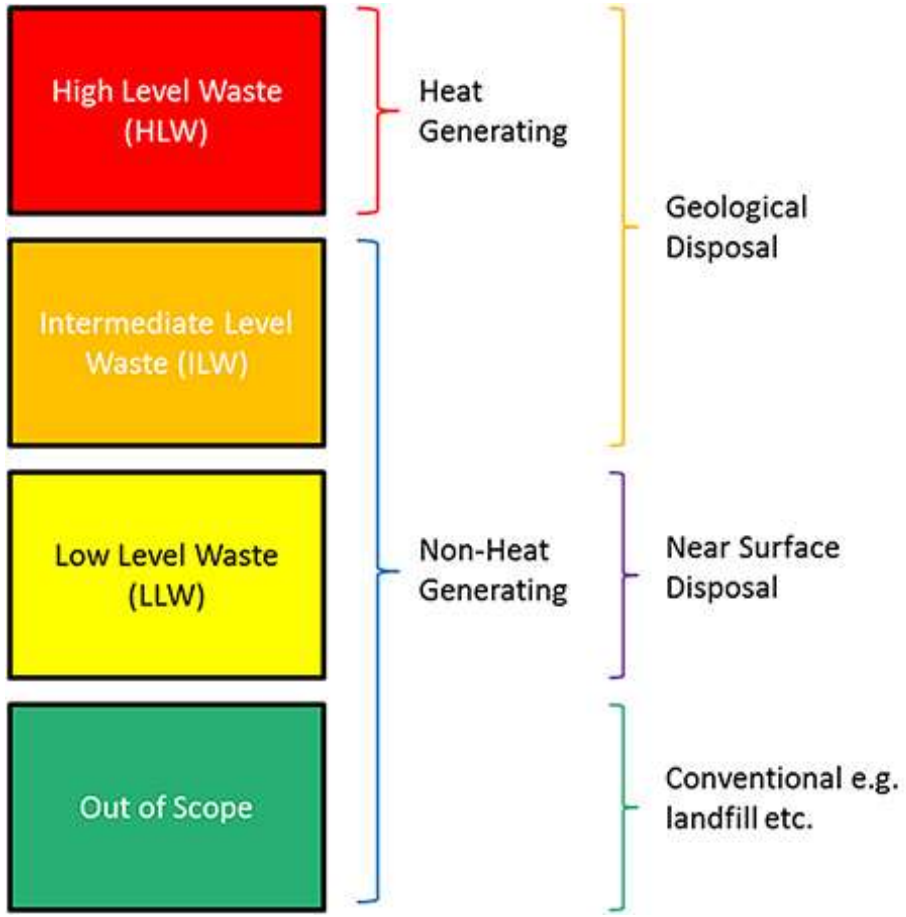
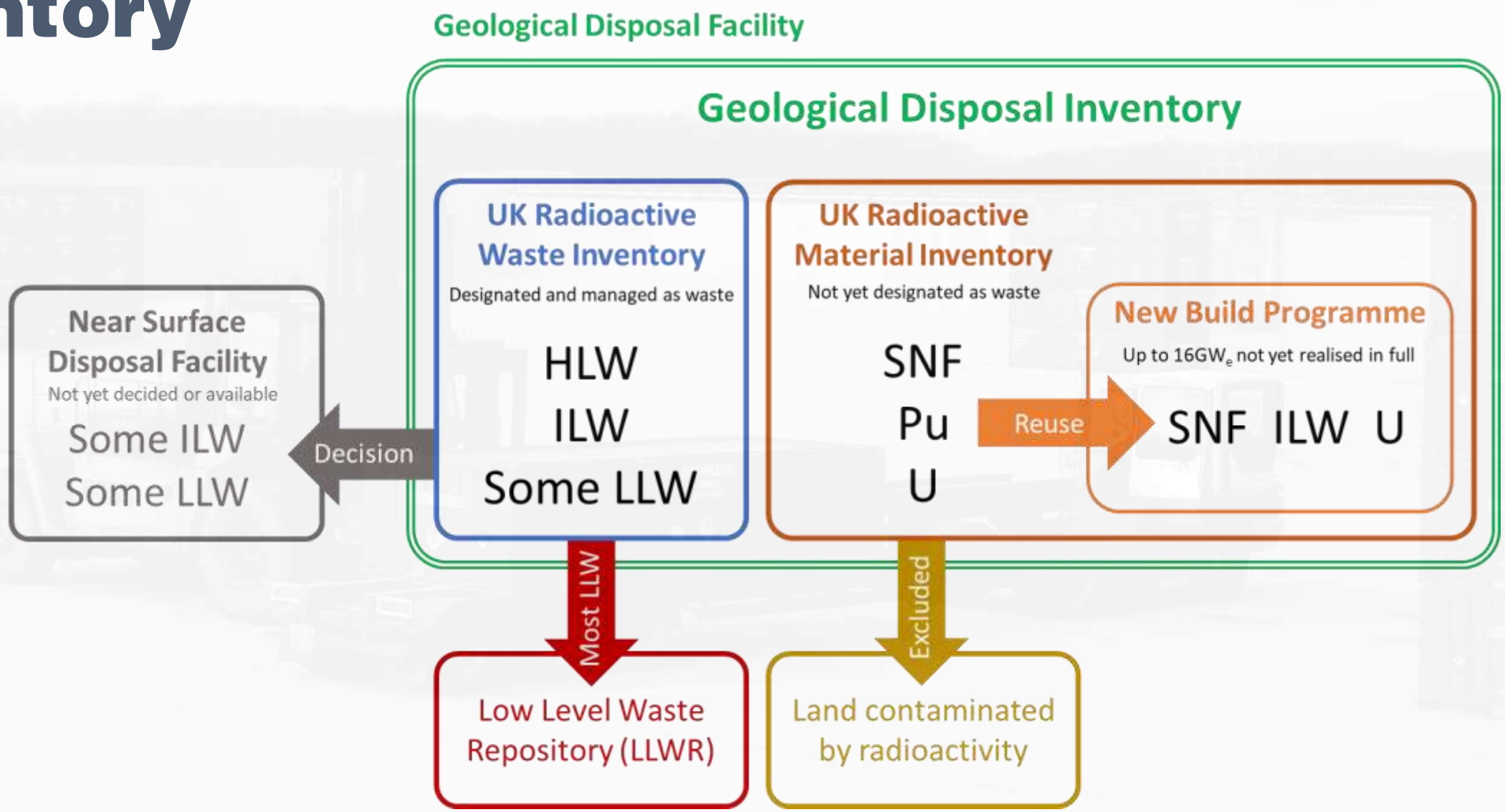
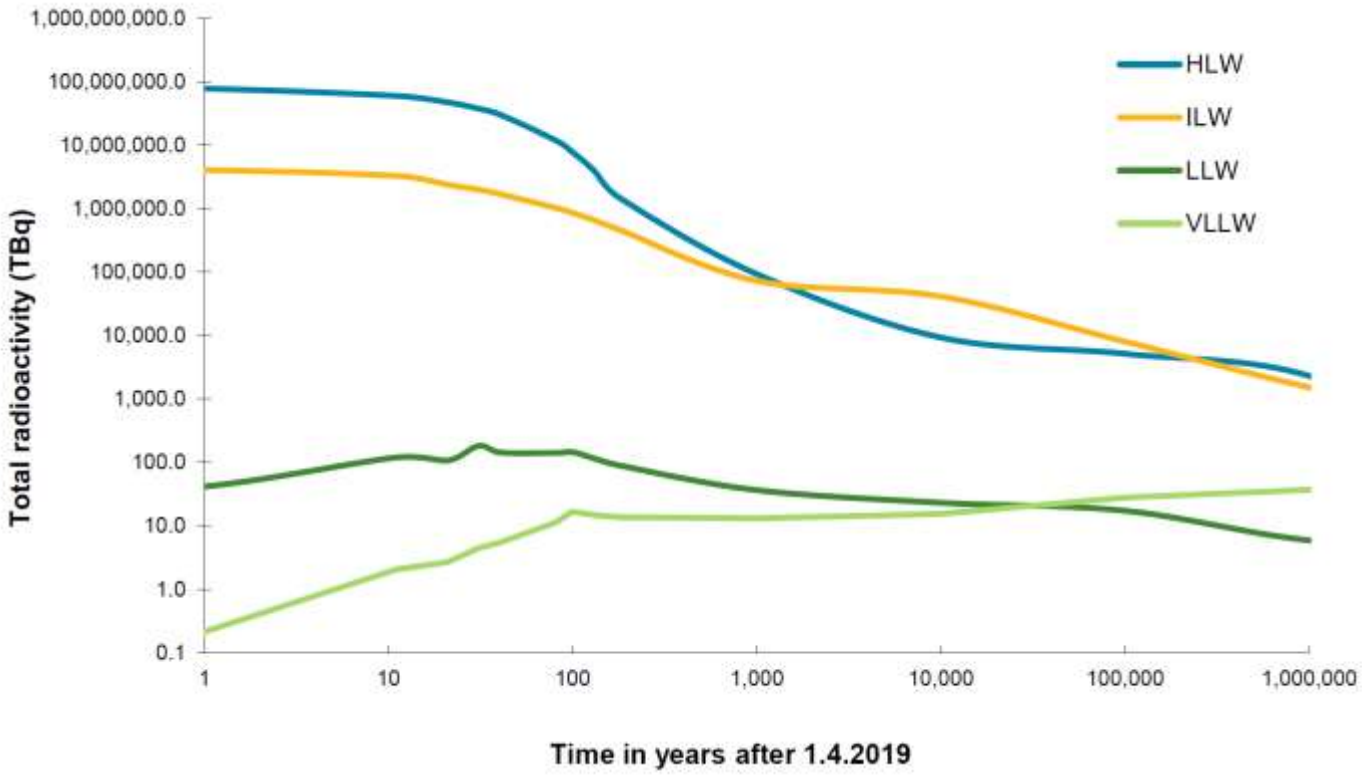


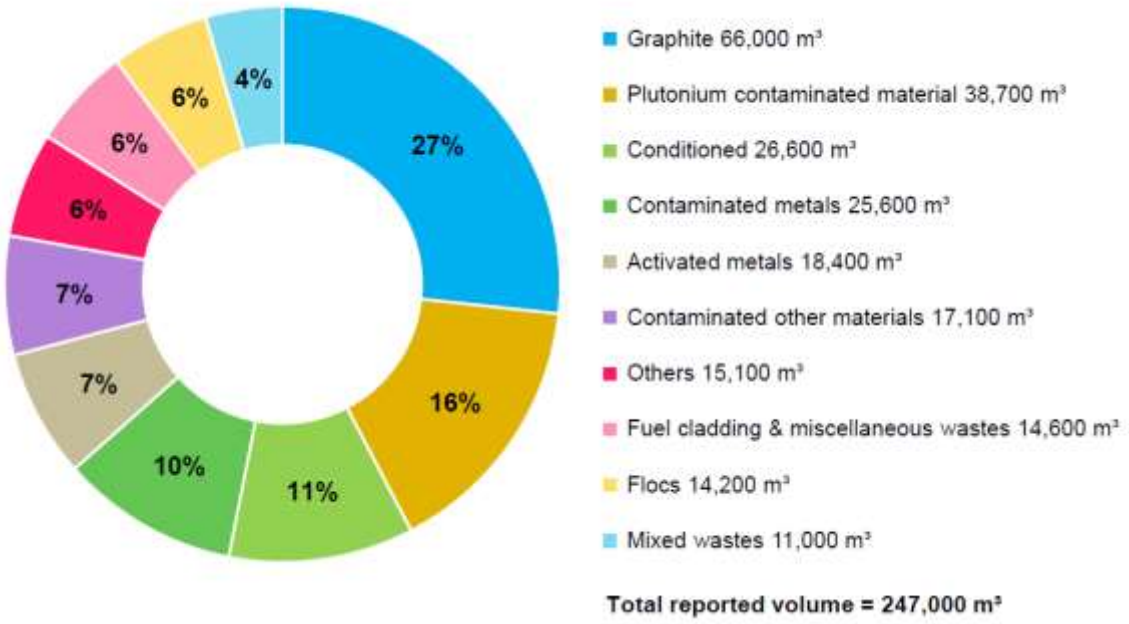
Inventory


Geological Disposal Facility
Geological Disposal Inventory
UK Radioactive Waste Inventory
Designated and managed as waste
HLW
ILW
Some LLW
UK Radioactive Material Inventory
Not yet designated as waste
SNF
Pu
U
Reuse
New Build Programme
Up to 16GWe not yet realised in full
SNF ILW U
Near Surface Disposal Facility
Not yet decided or available
Some ILW
Some LLW
Decision
Most LLW
Excluded
Low Level Waste Repository (LLWR)
Land contaminated by radioactivity

Radioactive Decay



ILW makeup



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Volume of UK Waste now and projected to arise over next 100 years

~10% by volume to GDF 500,500m^3

Waste category	Volume (m^3)		
	Reported at 1 April 2019	Estimated future arisings	Lifetime Total
HLW	1,790	-290	1,500
ILW	163,000	335,000	499,000
LLW	35,800	1,240,000	1,280,000
VLLW	799	2,690,000	2,690,000
Total	**202,000**	**4,270,000**	**4,470,000**

What does this look like in reality?

3,125x double decker buses

200x Olympic swimming pools

5x Royal Albert Hall auditorium

What does this look like practically?

A cube of 500,100m^3

Equivalent of the footprint of Wembley pitch and the height of Westminster Abbey

Wembley Stadium
Pitch Size 105m x 68m
(7,140m^2)
(roof height is 52m)

Westminster Abbey
Tower Height 69m

Legacy radioactive waste

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Fuel cladding

Plutonium contaminated materials

3 m^3 box for decommissioning waste

ILW stores (x3)

ILW from reprocessing and decommissioning.
Baseline treatment = cement encapsulation.

Vitrified HLW, stored at Sellafield

Spent nuclear fuel

AGR = long-term storage at ThORP (Sellafield)

PWR = dry cask storage (currently Sizewell B only)

Legacy vs Future Waste Arisings

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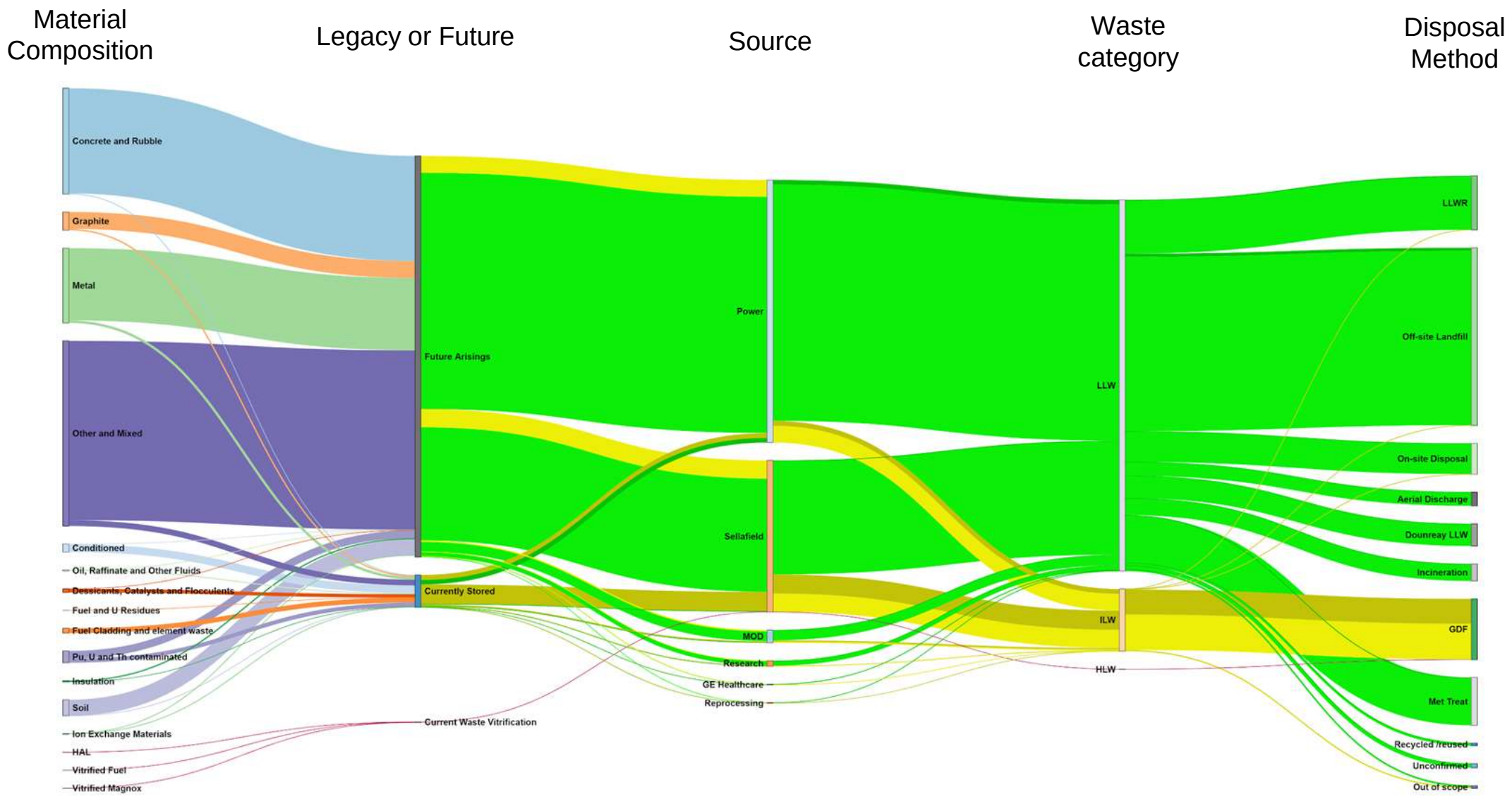

https://ukinventory.nda.gov.uk/

Legacy waste awaiting disposal

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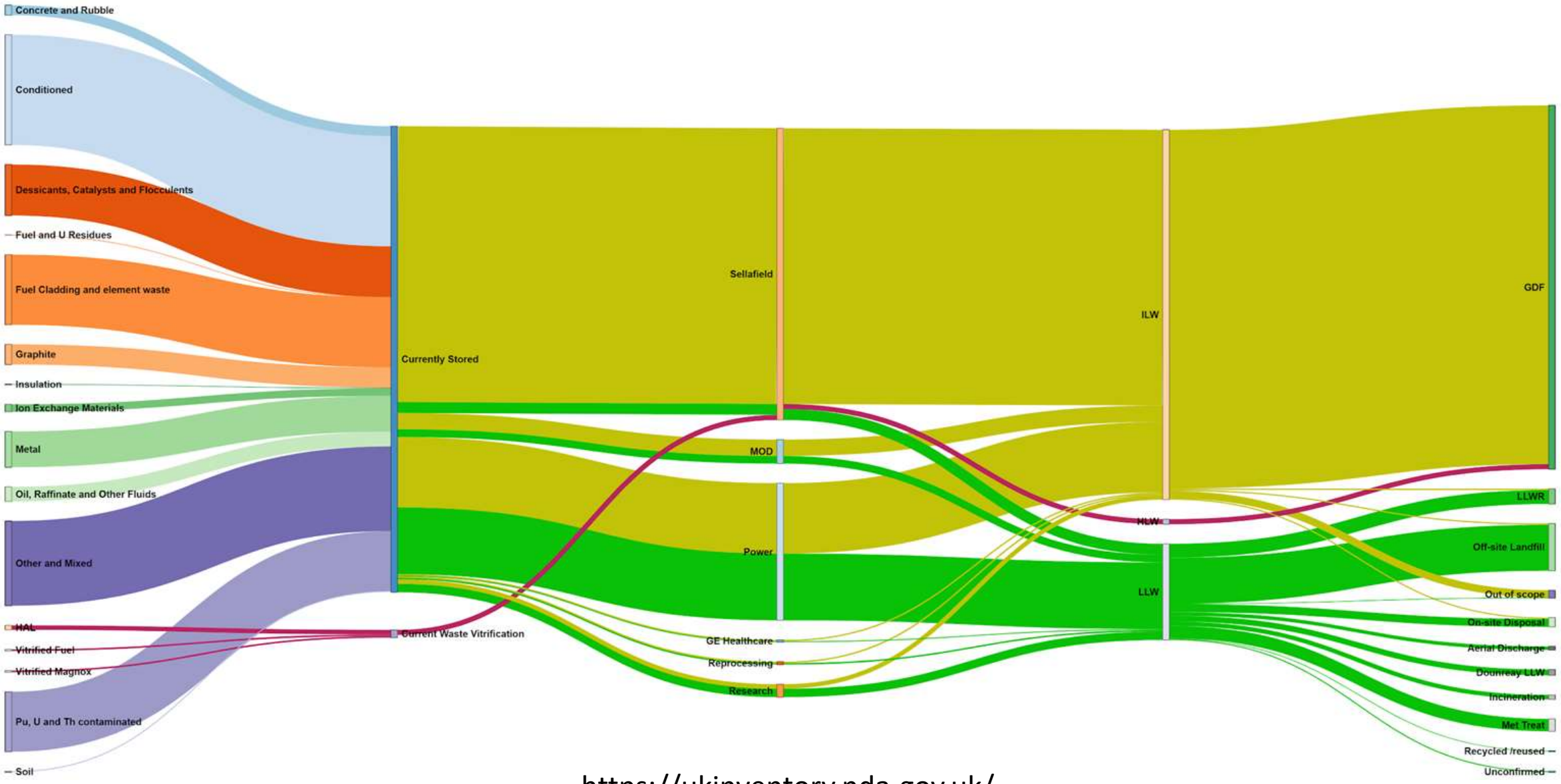
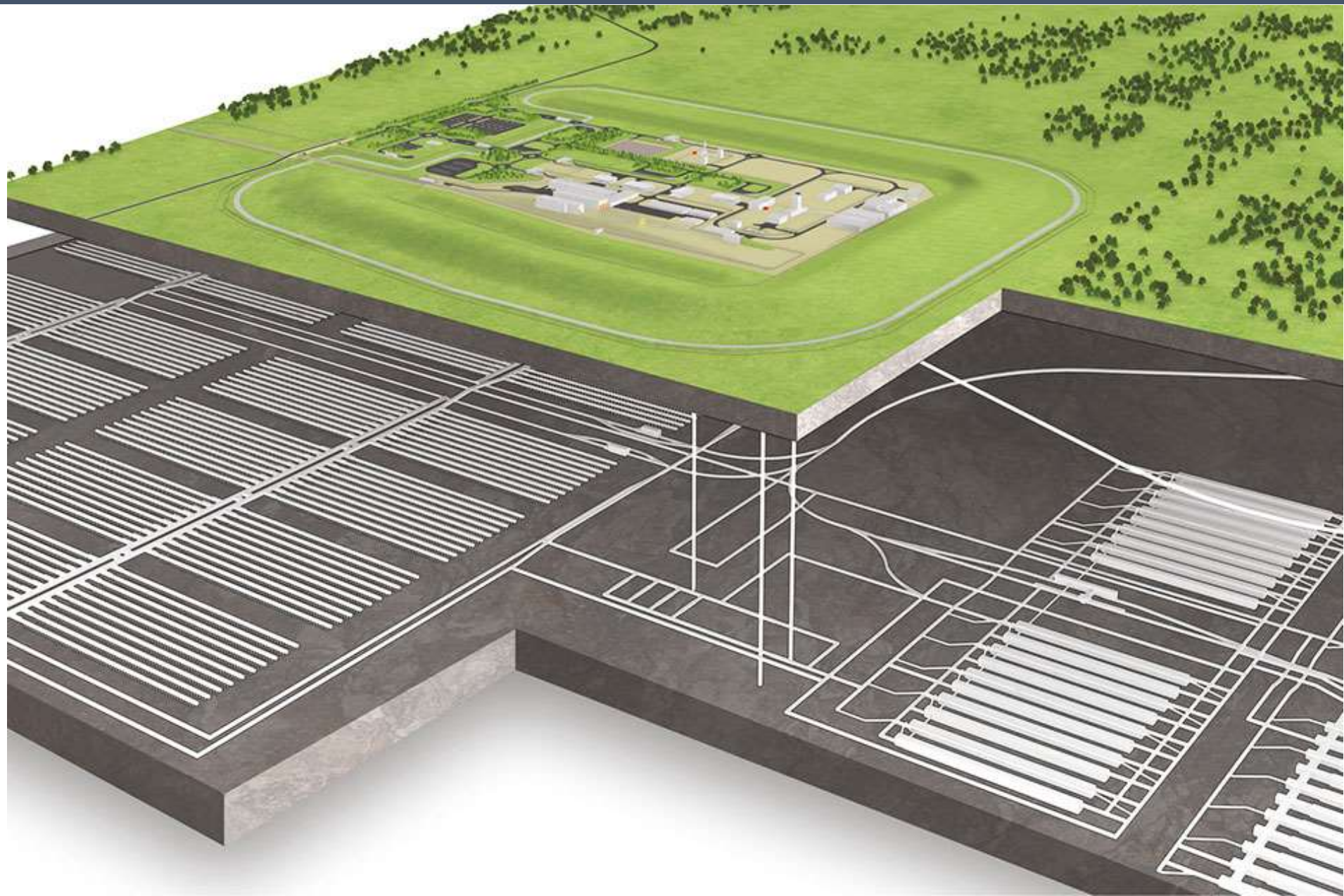
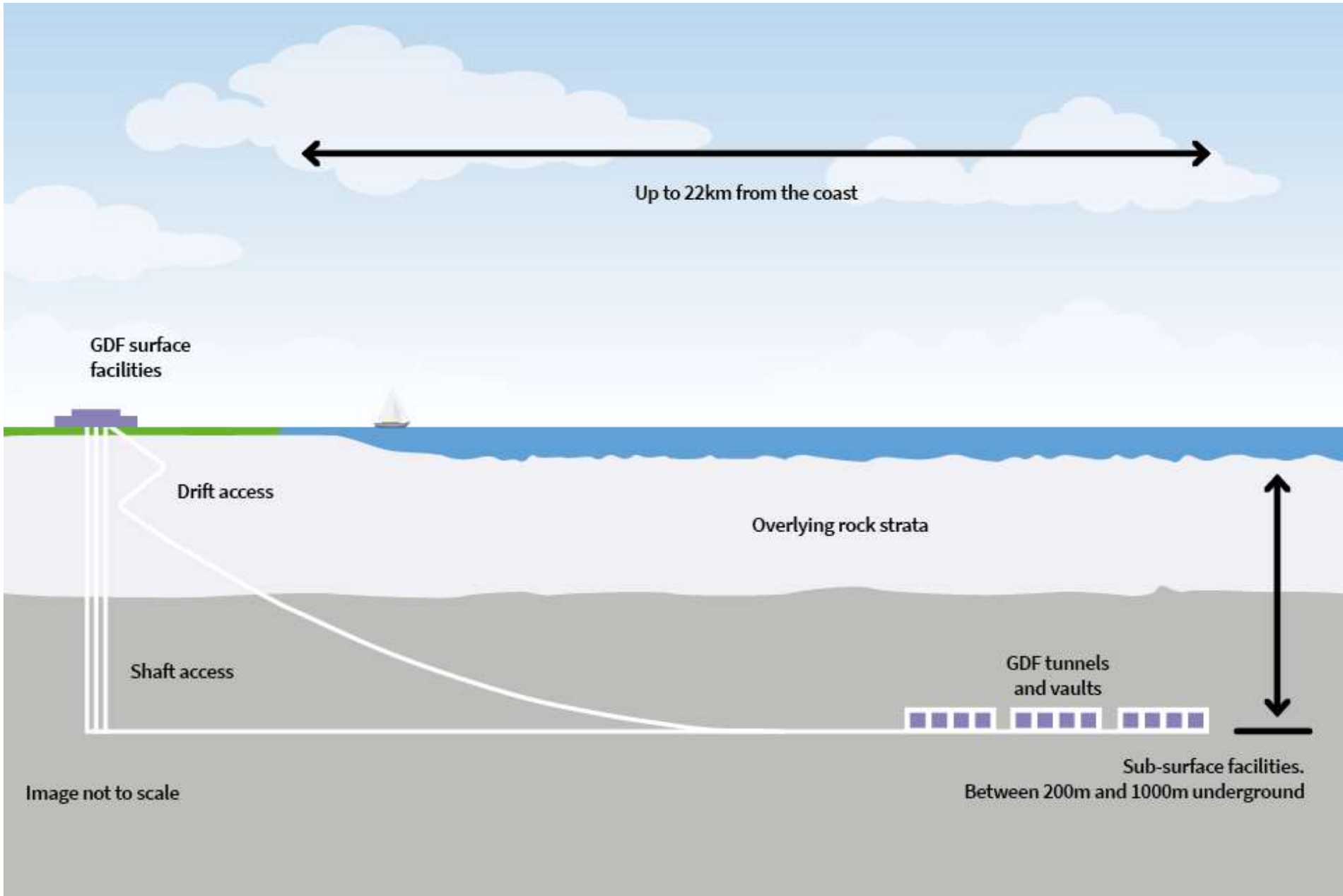


https://ukinventory.nda.gov.uk/

What a GDF might look like (onshore)



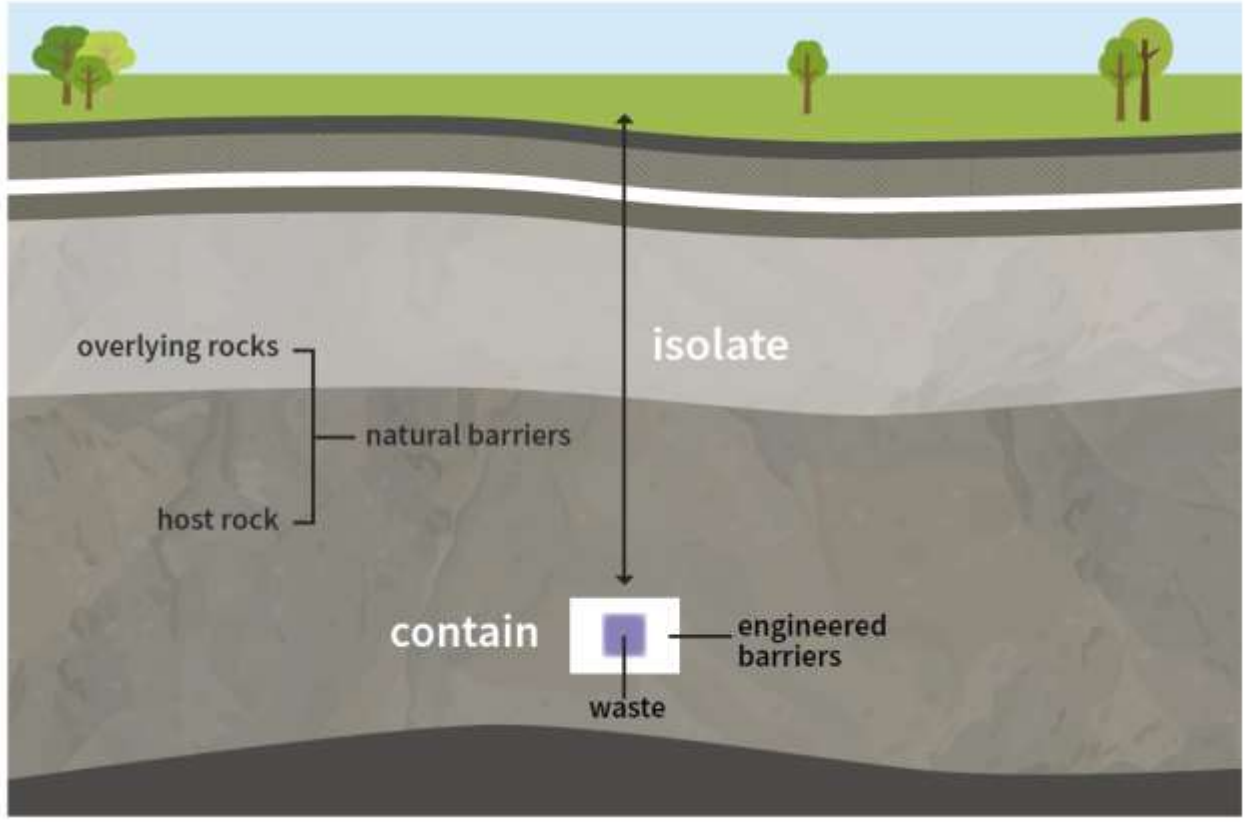
What a GDF might look like (nearshore)



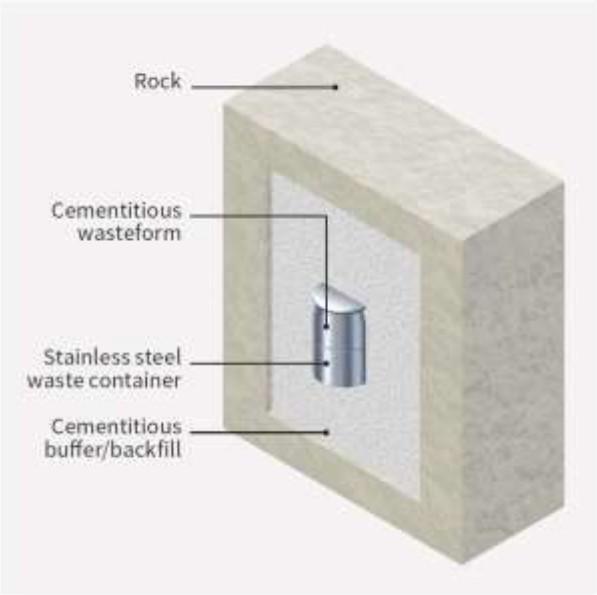
Multi-barrier Approach

Works by:

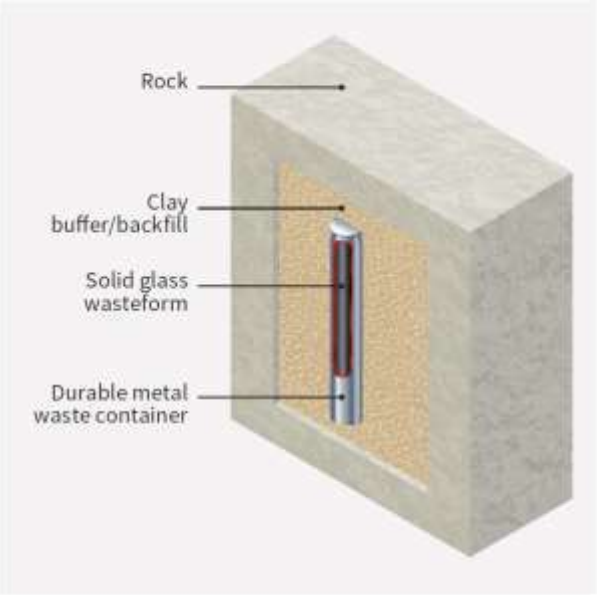
1. Solid waste
2. Encapsulated in suitable wasteforms (e.g. glass or concrete)
3. Placed in robust containers (e.g. steel or concrete)
4. Surrounded by suitable backfill material (e.g. bentonite clay)
5. All tunnels and vaults backfilled and sealed
6. Isolated under hundreds of metres of rock



Intermediate Level Waste



High Level Waste



Screening & Selection Criteria

- Rock type
- Rock structure
- Groundwater
- Natural processes
- Resources

Lower Strength Sedimentary Rocks

Mudstone & Clay

Higher Strength Rocks

Granite & Slate

Evaporites

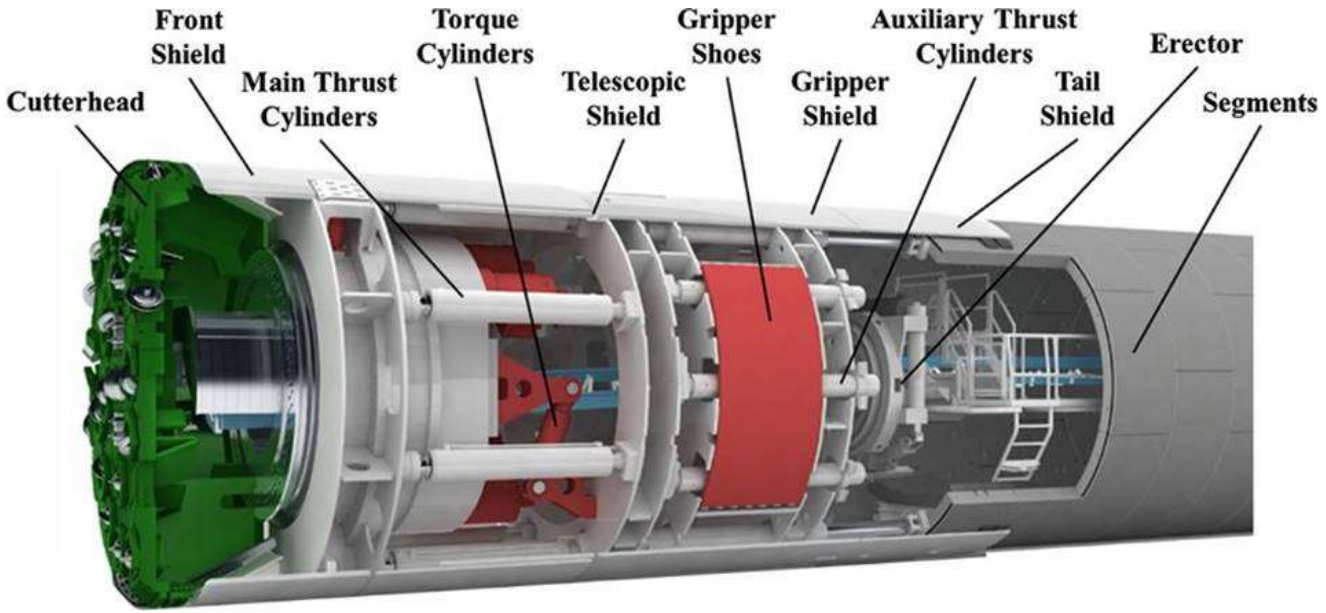
Rock salt

How would a GDF be constructed?

Access shafts up to 1,000m deep

How would a GDF be constructed?

Access drift tunnel and main tunnels



How would a GDF be constructed?

Caverns, Chambers and Shafts

The Journey to Geological Disposal

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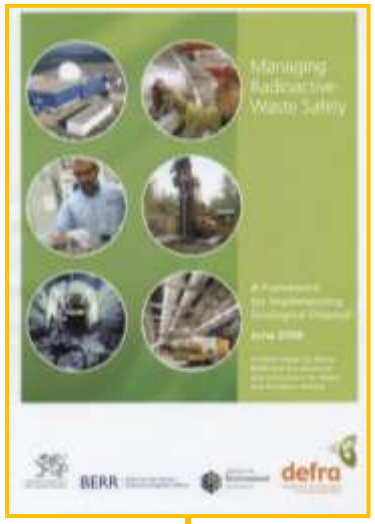
Government set up an independent group to oversee a review of options for managing solid radioactive waste in the UK



Siting Review started Jan '13

Consultation on new siting process published Sept '13

National Geological Screening

Preparing to work with communities

Developing land-use planning processes

2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021

CoRWM published integrated package of 15 recommendations

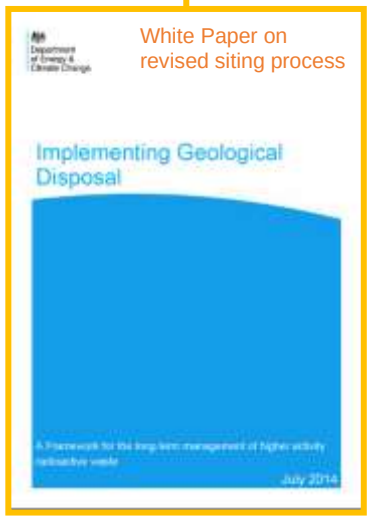
1. Geological disposal as an end point for long-term management of radioactive wastes
2. Robust storage in interim period with provision against delay or failure in reaching an end point
3. To expand the R&D programme
4. Need for a staged process with flexibility in decision making and partnership with communities willing to participate in siting process (voluntarism)

West Cumbria MRWS Process of voluntarism

Agreement required of borough, county and UK Government.

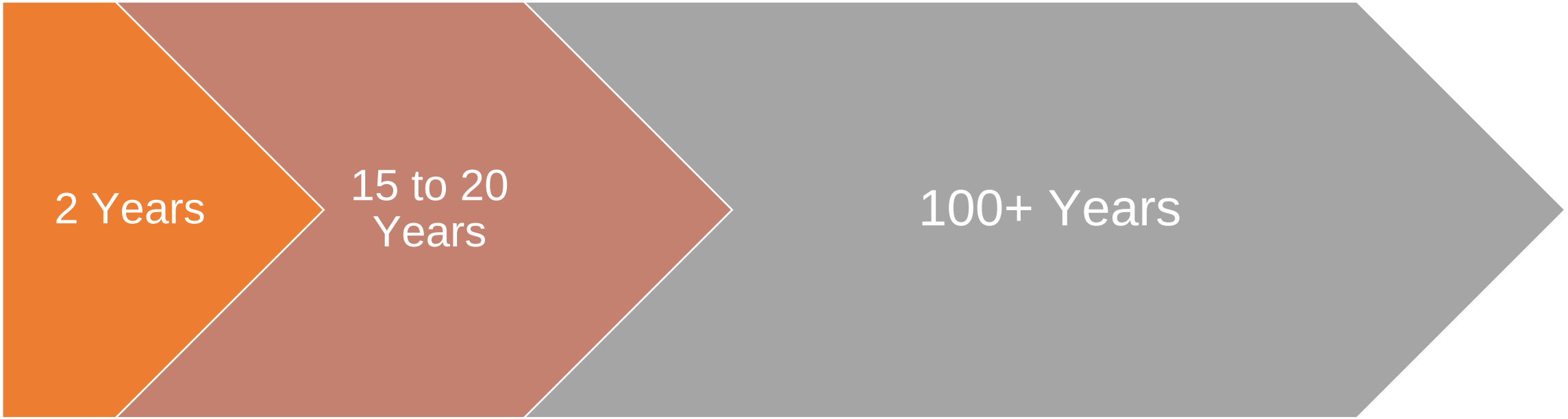
Borough's said Yes
County said No

White Paper on revised siting process



Working Group Process Launched

Indicative Timetable



1. National Geological Screening
2. Preparing to work with communities
3. Developing land-use planning processes

1. Talking to communities
2. Providing information & investment
3. Site Investigations
4. Designing and planning for a facility

1. Construction: site identified, job opportunities and local investment
2. Operation: continued opportunities and local investment
3. Closure: Radioactive waste safely disposed

What is the International Situation?

Consistent with International Consensus

In line with its 2006 in-depth assessment, CoRWM continues to consider that deep geological disposal is the best long-term solution for safely dealing with the UK's inventory of Higher Activity Waste.

International consensus

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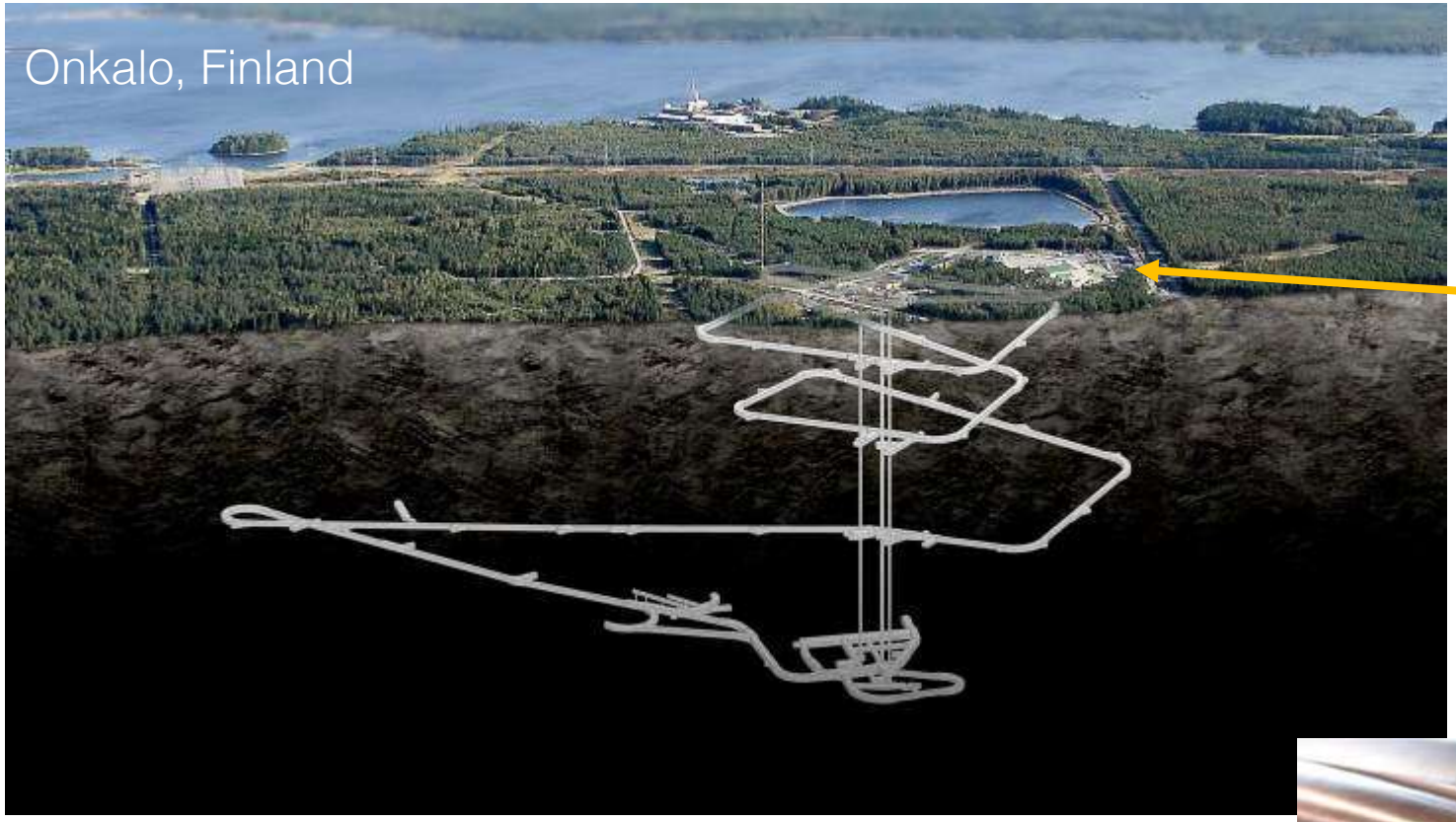

Spent nuclear fuel containers destined for disposal in tunnels at Onkalo at 475 m level

CoRWM Facilitating dialogue on key challenges through open exchange with stakeholders

Coming soon…

- CoRWM-hosted virtual stakeholder events
- Each event focused on a single topic, e.g. inshore disposal etc.
- Invited speakers to share a variety of perspectives
- Q&A session
- Up to 250 participants

Sir Nigel Thrift and Dr Claire Corkhill presenting at the NDA Integrated Waste Management Programme Stakeholder Event, Nov 2020.

Finally…

What does radioactive waste look like?

Why will it take SO long to have a GDF? Is this a political problem rather than a technical one?

How long can radioactive waste stay at Sellafield?

What will happen to the radioactive waste if there is no GDF? Is there a Plan B?

Why would communities volunteer to host the GDF?

How much radioactive waste is there?

Can we use radioactive waste for something else instead of disposing of it?

How big will a GDF be?

Is the community incentive really a bribe?

Why doesn't anyone ever talk about radioactive waste?

What are the impacts on human health if the radioactive waste was exposed to the environment?

Which factors are taken into account when selecting the geology? What will happen if there is an earthquake? Or sea level rise?

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Thank you