GDF

Inventory for a GDF:

2022 Inventory for Geological Disposal: summary

Nuclear Waste Services

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About the Inventory for Geological Disposal

The Inventory for Geological Disposal is a catalogue of everything that may one day need to be disposed of in a Geological Disposal Facility, or GDF.

At Nuclear Waste Services (NWS), it's our job to design and build a GDF to protect people and the environment from radioactive waste. (Specifically those wastes that will stay the most hazardous for the longest time.)

To plan for a GDF, we need to know how much radioactive waste it may have to contain. That's why the Inventory for Geological Disposal is important.

Want to get technical?

This is a summary of a highly technical report to aid understanding.

To find out more, take a look at the 2022 Inventory for Geological Disposal: Main Report if you're interested in seeing more of the data.

Inventory of past, present and future

Most of the radioactive waste destined for a GDF already exists. But it's likely to take 100–150 years to find a site, build, fill, and eventually close a GDF. In that time, the UK will produce more radioactive waste, and some of that will need to be disposed of in a GDF.

So the Inventory for Geological Disposal is part stock-take, part estimate:

- we catalogue how much existing radioactive waste needs to be disposed of in a GDF; and
- we scientifically estimate how much more waste will be added to the catalogue.

Every three years, we take stock again, so our work on designing a GDF is always based on up-to-date information.

There are two inventories for radioactive waste in the UK:

UK Radioactive Waste and Materials Inventory (UKRWI):

Details all the radioactive waste in the UK (already existing and expected from existing facilities). Updated every three years. When people in the nuclear industry talk about "the UK Inventory", they usually mean the UKRWI, not the Inventory for Geological Disposal.

Inventory for Geological Disposal (IGD):

The IGD is based on the UKRWI. However, it only catalogues the radioactive waste destined for disposal in the UK's GDF. It is updated every three years, based on the latest UKRWI, government policies, strategies and industry plans

Figure 1: Sources of nuclear waste.

The plan to deal with radioactive waste

All radioactive material naturally gets less and less radioactive over time.

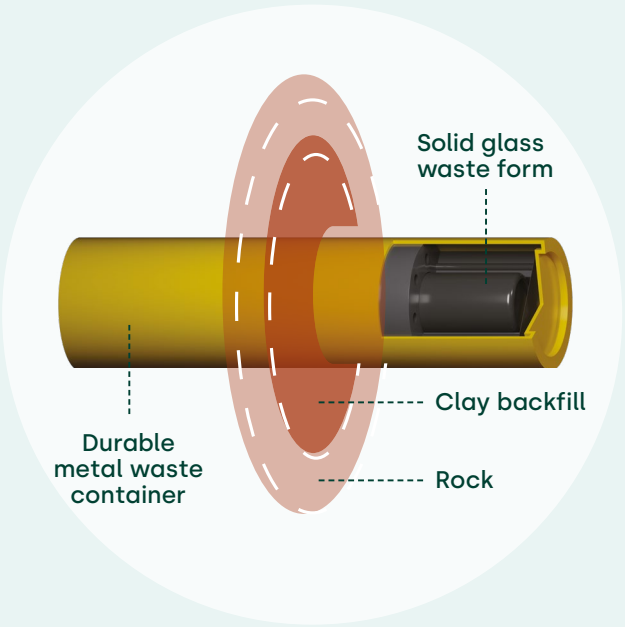
But some radioactive waste is so radioactive today that it will still be dangerous to be around hundreds of thousands of years from now.

For decades, scientists around the world have been working on the problem of what to do with the most hazardous radioactive waste.

The solution most scientists agree on today is geological disposal.

Geological disposal means permanently disposing of waste in a specially designed facility – a Geological Disposal Facility, or GDF – built into a suitable kind of rock formation, deep underground.

Figure 2: The multi-barrier approach.



Layers of protection

A GDF uses a multi-barrier approach in which engineered and natural barriers work together to isolate and contain the waste, keeping it safe and secure over the many thousands of years it will take for the radioactivity to naturally decay.

Containers: solid radioactive waste is sealed into secure, stable containers made of durable materials such as copper, steel, or concrete.

Buffer or backfill: the containers are placed in a series of highly engineered **vaults and tunnels**, built directly into a layer of ancient, stable rock, deep underground. Then any remaining space around the containers in the facility is filled back in with more rock, special clay or cement backfill.

Geology: the ideal host geology is naturally good at isolating and containing radioactive waste, because it has very low permeability to fluid. Granite, clay, and halite are examples of rocks found in the UK that have the right properties.

Seals: finally, the whole facility is permanently closed, providing passive safety into the far future.

Once a GDF is closed, the multiple barriers work together to ensure safety over the thousands of years it will take for the radioactivity to naturally decay to levels that won't cause harm. It is passively safe, as it requires no interaction, and no ongoing maintenance while the radiation decays.

Tailored to fit

The UK isn't the only country working on a GDF. Experts and scientists from around the world agree the safest permanent solution for radioactive waste is geological disposal.

A number of countries, including Sweden, Finland, France, Canada and Switzerland, are implementing plans for GDFs, which involve isolating such waste many hundreds of metres underground.

Each GDF is based on the same overall idea: multiple barriers working together to isolate and contain the waste. But the exact design of each one will be unique. Things like the number and position of the vaults and tunnels are affected by:

- the geology: the type, depth, size and shape of the rock formation the GDF is built into;
- the inventory: what types of waste are being disposed of, how much of each type, and what sort of containers it will be in.

That's where understanding the Inventory for Geological Disposal comes in.

Where the waste is:

574 waste streams* in the Inventory

* A waste stream includes waste or a collection of waste items at a particular site, usually in a particular facility and/or from a particular process or operation.

- Spent Fuel reprocessing
- Nuclear Power Reactors
- Nuclear Energy R&D
- Defence
- Medical & industrial
- Waste disposal facility

The 2022 Inventory for Geological Disposal

337,000 m³

This is the volume of just the radioactive waste itself.

521,000 m³

This is the volume of the waste, plus the material we mix it with to solidify (or 'immobilise') it.

769,000 m³

This is the volume of the packaged waste in its final form for disposal, and it is how much space it will take up in a GDF.

This estimate is based on the position in 2022 and is kept under review.

How much radioactive waste is destined for disposal in a GDF?

	Radioactivity at 2200 (TB_q)	Packaged Volume (m^3)
High Level Waste	4.05%	1.22%
Intermediate Level Waste	4.92%	62.24%
Low Level Waste	0.0001%	0.004%
Spent Fuel	90.91%	11.52%
Plutonium	0.09%	0.08%
Uranium	0.02%	24.94%

Immobilising and packaging radioactive waste

Some solid radioactive waste is irregularly shaped, like dismantled reactor components. We need to set this waste into solid blocks, both to contain the radioactivity, and to make it easier to stack for transport and disposal.

Other radioactive waste is liquid, or semi-liquid sludge. It needs to be made solid so we can be sure it'll stay where we put it. We call this 'immobilising' the waste. There are different ways to do it depending on the type of waste, including:

- mixing high activity liquid waste with glass, firing the mixture in a furnace and pouring the molten mixture into a steel container;
- mixing intermediate level wastes with cement powders and stirring them to disperse them through a solid cement block;
- putting the waste in various containers and pouring in cement, which fills the gaps and hardens.

The kind of container and immobilisation option depends on the kind of waste. However, all the waste packaging options must meet our published specifications.

The immobilised waste and container are the first barrier that forms part of the design of a GDF.

How much waste is legacy, and how much will new nuclear add?

New nuclear is based on up to 24 gigawatts utilising existing technologies.

From existing sites

of total packaged volume for a GDF.

Expected from new nuclear power stations

of total packaged volume for a GDF.

The UK's nuclear legacy

Most of the radioactive waste destined for disposal in a GDF already exists today.

For more than 70 years, nuclear technology has been a part of our lives in the UK. It currently provides around 15 per cent of the UK's electricity and is used in industry, medicine, research, and defence. All these activities produce radioactive waste.

For now, this existing waste is being kept at safe, secure, specially designed facilities all around the UK – mainly at Sellafield in Cumberland.

Today, nuclear power is viewed by the UK Government as essential to the low-carbon energy mix and securing our energy supply in the future. The Welsh Government also supports nuclear new build. NWS will provide for the safe disposal of waste already created over the past 70 years – and will enable the UK to increase nuclear energy capacity by preparing to safely dispose of future waste.

Just how radioactive is the waste?

GDF	
Low heat generating waste area	**High heat generating waste area**
– Robust shielded containers – Shielded intermediate and low level waste – Unshielded intermediate and low level waste – Depleted, natural and low enriched uranium	– Spent fuel – High level waste – Highly enriched uranium* – Plutonium
87% of packaged volume	**13% of packaged volume**
5% of radioactivity	**95% of radioactivity at 2200**

* Highly enriched uranium doesn't actually give off significant heat, but has other properties that mean it's best disposed of in the high heat generating waste area.

High and low heat generating waste

Some types of radioactive waste are hotter than others.

In the Inventory for Geological Disposal, we divide the waste destined for a GDF into 'high heat generating' and 'low heat generating' waste.

These categories are important because high and low heat generating wastes need to be disposed of in different ways, in different areas of a GDF. For example, packages of high heat generating waste need to be adequately spaced from each other, to manage the heat output from the waste.

The packaged volume of the high heat generating waste is approximately one tenth of the waste in a GDF. But, it'll account for about 95% of the radioactivity a GDF will protect people from at the time we close it in 2200.

High heat generating waste includes used nuclear fuels, plutonium, highly-enriched uranium and the high-level waste that remains after reprocessing used nuclear fuels. Low heat generating wastes make up the rest of the inventory and include wastes from the operation and decommissioning of reactors such as fuel cladding, reactor components and items that have been contaminated.

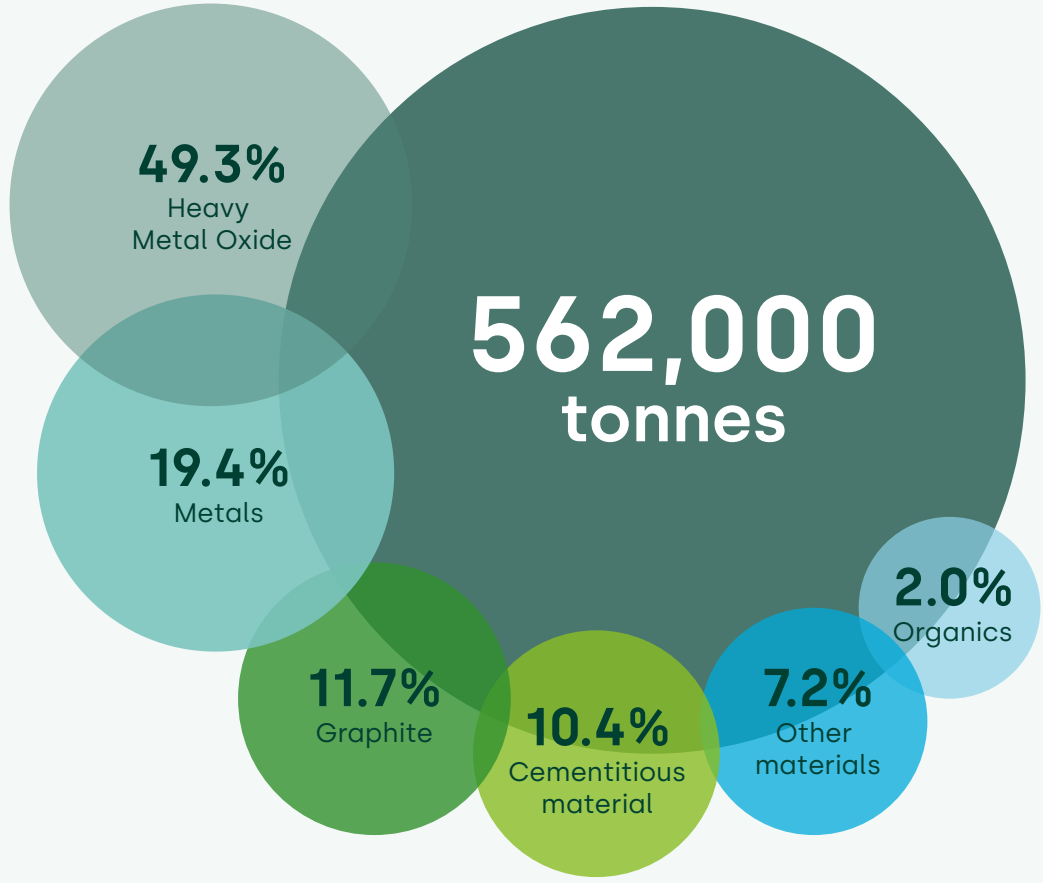


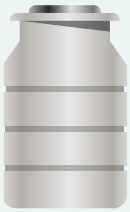
Figure 3: Composition of the Inventory by material.

What's new in the 2022 Inventory?

Between this Inventory for Geological Disposal and the previous one in 2019, the size of the assumed new build programme increased from 16 GWe to up to 24 GWe. Disposing of this waste in a GDF will enable the UK's ambition to increase its nuclear energy capacity by preparing to safely dispose of future waste.

Because of this, the 2022 Inventory includes about 50% more spent nuclear fuel from new nuclear power stations than the 2019 Inventory. (Spent fuel was already a relatively small percentage of the waste volume destined for a GDF.)

The predicted packaged volumes of some other wastes have decreased. This is a result of multiple factors including changes in packaging assumptions by waste producers and improvements in inventory estimates. To learn more, please refer to the "2022 IGD: Key Changes Report".



Intermediate Level Waste (ILW)

High Level Waste (HLW)

Figure 4: Packaged radioactive waste (not to scale).

How accurate is the estimate for the Inventory?

Some of the figures in the Inventory for Geological Disposal are based on waste that is already packaged and in storage, so can be measured.

Others are based on informed assumptions about:

- how the volume of the waste will change after it's immobilised and packaged;
- how much waste we expect to come from nuclear sites to be decommissioned, still running or that haven't been built yet.

We base these assumptions on things like:

- the UKRWI, which tells us how much waste there is (and is likely to be) from existing nuclear sites;
- data from organisations whose work produces radioactive waste, or which immobilise and package the waste;
- the UK Government and devolved administration's policies and strategies on managing radioactive substances and nuclear decommissioning, which tell us how much waste to expect and what form it will take.

Generally, we assume that everything laid out in these strategies and policies will go ahead as planned. The figures in this summary are based on that assumption (scenario A, which we sometimes call the reference scenario).

But just to plan for all eventualities, we also look at other plausible scenarios (scenarios B and C). This helps us make sure that our designs for a GDF allow for the possibility of things changing in the future.

Scenario	A few examples of our assumptions
A (reference)	– The UK builds up to 24 GWe of new nuclear power stations – The Sizewell B power station electricity generation ends in 2035 and is decommissioned by 2053 – The UK continues to enrich uranium until 2039
B	– Same as scenario A, except we also need to dispose of more depleted uranium tails from the enrichment of new nuclear fuel
C	– Same as scenario A, except: – The UK only builds 16 GWe of new nuclear power stations – Depleted, natural and low enriched uranium is not disposed of in a GDF – Thermal treatment technology improves so we can treat some waste, reducing the volume for disposal in a GDF – Some wastes can be disposed of in a near-surface disposal facility

What the 2022 Inventory means for communities

We're still a long way off actually disposing of the waste described in the Inventory for Geological Disposal.

At the moment, we're working to find a suitable site with a community willing to host a GDF.

So what can a community take from the 2022 Inventory for Geological Disposal?

We keep the waste destined for a GDF to a minimum

A GDF won't be taking all the UK's radioactive waste. Geological disposal is only for the small fraction of radioactive waste we can't reuse, recycle, treat, or dispose of another way. We call this 'application of the waste hierarchy'.

As a result, less than 10% of the volume of radioactive waste in the UK is currently planned for disposal in a GDF.

Figure 5: Volume of waste (as stored) from different sources, and disposal routes for these wastes.

The waste doesn't look as you might expect

A large proportion of the waste present in the IGD is composed of everyday materials such as:

- metals used in the internal components of nuclear reactors and nuclear facilities;
- cementitious materials, either as part of the waste, or used to immobilise the waste in the containers;
- graphite from the cores of older reactor designs.

Additionally, there is a large quantity of uranium, which is currently present in various forms, such as powder, ceramic or metal.

Radioactive waste looks nothing like what you might see on TV – it doesn't look like barrels leaking green liquid emblazoned with radiation hazard signs.

Any waste that started out as a liquid or sludge will be solid, safely and securely packaged into containers long before it arrives for disposal in a GDF.

We know how much waste to expect

Most of the waste destined for a GDF already exists. It's being kept in safe, secure storage facilities. Some is waiting to be immobilised and packaged for disposal, and some already has been.

We have a good idea of how much more waste there is to come from existing and new nuclear sites. It's a relatively small portion of the waste destined for a GDF.

Even the government's announcement of new nuclear power stations hasn't increased the Inventory for Geological Disposal by that much, but we're keeping this under review within our waste management plans.

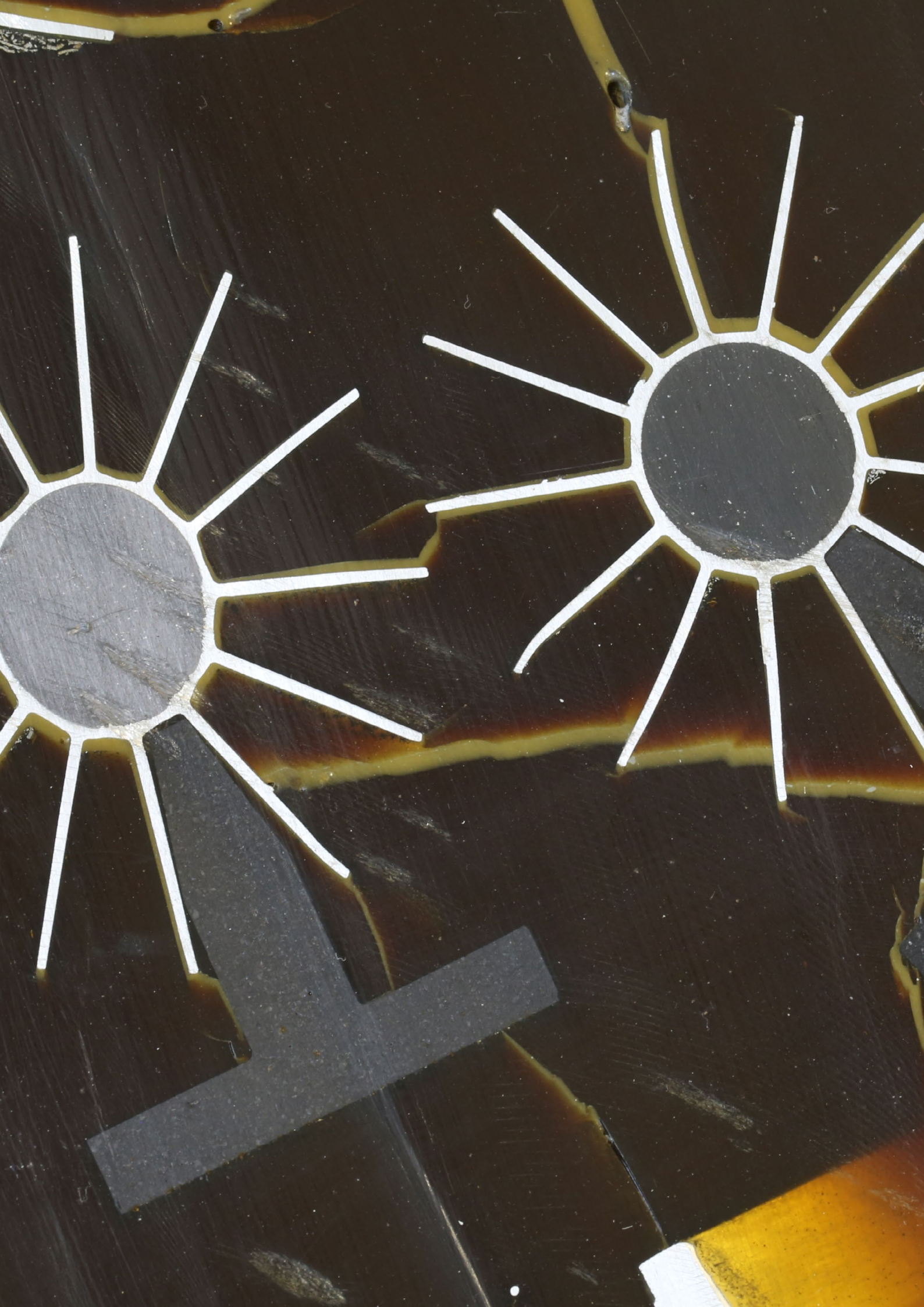
So while the volumes of waste may change, the reasons for changes are understood and the safety of a GDF is unaffected.

The Inventory is always under review

Packaged waste and passive safety are the cornerstones of assuring the safety of a GDF and keeping communities' trust.

So we'll keep producing a new Inventory for Geological Disposal every three years, like we've been doing since the 1980s. That way, NWS and communities will always have up to date information about the waste destined for a GDF.

The next Inventory for Geological Disposal will be based on the 2025 UK Radioactive Waste and Materials Inventory.



Nuclear Waste Services

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