

Consultation on ISOLUS Outline Proposals (CIOP)

Autumn 2003

Centre for the Study of Environmental Change,
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Background Information

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INFORMATION ABOUT NUCLEAR-POWERED SUBMARINES AND PROJECT ISOLUS

About UK nuclear-powered submarines

The UK currently has 27 nuclear-powered submarines. 16 of these are in service, and 11 are "laid-up" (no longer in service). 3 more nuclear-powered submarines (the Astute class) have been ordered, the first of which is currently being built at Barrow-in-Furness, Cumbria. 3 further Astute class submarines are planned, subject to ministerial approval. Not all nuclear-powered submarines may carry nuclear weapons.

See 'About UK nuclear-powered submarines' on page 5 (this section includes some information about other countries' nuclear-powered submarines).

A nuclear-powered submarine is powered by a nuclear reactor. The rationale given for using nuclear reactors to power submarines is that nuclear-powered submarines are able to stay submerged for long periods. In effect they can circumnavigate the globe without the need to refuel, and so "combine speed, endurance and stealth" (MoD).

“Unseen and unheard, the Royal Navy's submarine force can strike against ships and submarines, as well as supporting land operations against targets with TLAM [Tomahawk missiles] up to 1000 miles away with pinpoint accuracy, and providing the Nation's Strategic Nuclear Deterrent [with Trident missiles]” (MoD Royal Navy Subs website)

The 1997 Strategic Defence Review concluded that

- the number of nuclear-powered submarines in service could be reduced by 2
- the submarines remained 'a potent and effective force at the heart of Britain's defence capability.' (Strategic Defence Review, July 1998, Factsheet No. 26, Royal Navy/Attack Submarines)

Existing nuclear-powered submarines should only need to refuel once or twice, dependent on class, in their 25-30 year lifetime. Refuelling involves cutting a hole in the top of the submarine, removing the spent (used) fuel rods from the reactor and replacing them. Spent fuel rods are transported by rail to Sellafield in Cumbria¹ where they are stored. The site is regulated by the Nuclear Installations Inspectorate, and discharges are licensed by the Environment Agency.²

¹ Sellafield (originally called Windscale) is located on the coast of west Cumbria in the north of England. Spent fuel from civil and military nuclear reactors, including from submarines, is stored there. Some of the spent fuel from civil nuclear power stations is reprocessed there to extract the plutonium and uranium. Some radioactive waste is discharged into the Irish Sea. Sellafield is run by BNFL (British Nuclear Fuels Ltd), who also reprocess nuclear waste for other countries at the site.

² The **Nuclear Installations Inspectorate (NII)**, which is part of the Health and Safety Executive (HSE), is responsible for regulating activities on nuclear licensed sites. The **Environment Agency** is responsible for licensing discharges of radioactive materials. The **Chief Naval Nuclear Regulatory Panel (CNNRP)** is responsible for regulating activities on MoD nuclear sites.

What happens to nuclear-powered submarines that are no longer in service?

The UK has 27 nuclear-powered submarines. The MoD states that:

- 16 are still in service
- 11 have been defuelled and are being stored afloat -7 at Rosyth and 4 at Devonport

Submarines taken out of service undergo a process called 'Defuel, De-equip and Lay-up Preparation' (DDLp).

Defuel: the most highly radioactive material on board, the fuel, is removed and transported by train to Sellafield in Cumbria, where it is stored;

De-equip: equipment which is classified for security, or which can be re-used or disposed of, is removed;

Lay-up Preparation: the submarine (which still contains the Reactor Compartment - see below) is prepared for long-term storage afloat.

This has been done at Devonport and Rosyth. In future defuelling will only be carried out at Devonport. Devonport will also become the only UK site to refit nuclear-powered submarines that are in service.

By 2012 more submarines will have come out of service and there will no longer be enough practicable space at the existing berths to store them afloat at these dockyards. By 2040 all 27 of the current UK nuclear-powered submarines will have come out of service. Either more space for afloat storage will have to be provided somewhere, or an alternative means of storing the radioactive wastes will have to be developed.

What are the nuclear wastes from nuclear-powered submarines?

The radioactive waste from the submarines is in the Reactor Compartment and system pipework. The Reactor Compartment (RC) is roughly the middle slice of the submarine.



In size it is similar to 2 double-decker buses, has a diameter of 10 metres and weighs approximately 750 tonnes. The Reactor Compartment is therefore difficult to transport on land, but could be transported by water. Much of the rest of the submarine (the two halves minus the middle) could be recycled as scrap metal.

The Reactor Compartment (RC) contains the reactor pressure vessel and cooling system. These components are radioactive and will be classified as either Intermediate Level Wastes (ILW), Low-Level Wastes (LLW) or Very Low-Level Wastes (VLLW). (For further information, please see 'The UK Nuclear Waste

Classification System' on page 6 and 'Radioactive materials in the Reactor Compartment' on page 7.)

The spent fuel rods are removed from the nuclear reactor pressure vessel (within the Reactor Compartment) after the submarines have been taken out of service. This is similar to the process of defuelling submarines in active service. The spent fuel rods are transported by rail to Sellafield in west Cumbria, where they are stored. The spent fuel rods are not classified as waste because they could potentially be reprocessed at Sellafield. The management and transport of spent fuel is not being considered by the MoD in this project.

About the storage or disposal of nuclear wastes from nuclear-powered submarines

Current thinking and current options on the storage or disposal of nuclear wastes from nuclear submarines have been determined by events over the last few decades.

Sea disposal: The MoD had planned to dispose of nuclear-powered submarines at sea. However, this option was closed in 1993 when Britain became a signatory to the London Dumping Convention, which prohibited the disposal of Intermediate Level Radioactive Waste (ILW) at sea.

Storage afloat: After this, the MoD policy was to store afloat for a period of 30 years those submarines that were no longer in service. The assumption was that there would be an underground repository available for radioactive waste disposal by 2010.

Underground disposal: However, in 1997 the proposal for an underground laboratory to investigate the suitability of the Sellafield site in Cumbria for an underground repository was rejected. Now a "National Waste Management Facility" for radioactive wastes is not expected to be available until at least 2050, if at all. The question of a national disposal site is expected to become the subject of separate public consultations by the Department of the Environment, Food and Rural Affairs (Defra).

The MoD is therefore considering alternative options for the interim storage of the wastes. These options are described in the ISOLUS Review of Options prepared for the MoD by their Warship Support Agency (WSA; formerly called the Ship Support Agency). A printed copy can be obtained from:

Birch 1c #3131
MoD AbbeyWood
BS 34 8JH
Tel WSA secretariat
011791 32437
Fax 011791 32958

For more detailed information, please see:

- 'Brief history of MoD policy & options on the disposal/storage of nuclear waste,' page 8;
- Disposal or Storage,' page 10;
- Storage Options,' page 11; and
- Sites,' page 12.

The Current Situation

In February 2003 the MoD issued an invitation to industry to submit outline proposals for on land management of the radioactive submarine waste. (For more information, please see ‘About this Consultation’ in the Consultation Information document.) Five outline proposals were submitted, involving eight sites and different options with regard to the stage at which the reactor would be cut up. (For more information, please see ‘Proposals and Sites’ in the Lancaster University Summaries of Proposals and Sites document.)

The five proposals include three main strategies for managing the Intermediate Level Wastes (ILW) from the Reactor Compartment (RC).

Note 1: All options involve cutting the Reactor Compartment out of the submarine.

Note 2: The Reactor Pressure Vessel (RPV) contains most, but not all, of the ILW

- Store the RC intact for 30+ years. Then cut up the RC (including the RPV) and package all the ILW. (The advantage of waiting 30+ years is explained on the page Radioactive materials in the Reactor Compartment.)
- Cut up the RC (including the RPV) and package all the ILW soon after it has been removed from the submarine.
- Cut the RPV out of the RC immediately. Package the intact RPV and other ILW. Cut up and repackage the RPV at a later point.
- For further information about cutting up, storage and packaging see page 16

The MoD and potential contractors are considering different finance arrangements including Private Finance Initiative (PFI).

- For more information about PFI, please see ‘Finance Issues’ on page 14.

Further Information

Further information on UK nuclear-powered submarines

UK nuclear-powered submarines and the years in which the first in each class was launched:

1960: Dreadnought, the first British nuclear-powered submarine

1963: Five Valiant Class nuclear-powered submarines (Valiant, Warspite, Conqueror, Courageous, Churchill)

1966: Four Resolution Class nuclear-powered submarines, carrying Polaris nuclear missiles (Revenge, Resolution, Renown, Repulse)

1971: Six Swiftsure Class nuclear-powered submarines (Swiftsure, Sovereign, Superb, Spartan, Sceptre, Splendid)

1981: Seven Trafalgar Class nuclear-powered submarines (Trafalgar, Turbulent, Trenchant, Triumph, Torbay, Talent, Tireless)

1992: Four Vanguard Class nuclear-powered submarines, carrying Trident nuclear missiles (Vanguard, Vigilant, Victorious, Vengeance)

2001: Three Astute Class nuclear-powered submarines (Astute, Artful, Ambush)

Building the first of this class commenced in 2001. Construction of the second commenced in 2002. The MoD is considering plans for a second batch of up to three more of these potent boats. (<http://www.royal-navy.mod.uk/static/pages/461.html>)

There are two classifications of these submarines:

- SSN (Ship Submersible Nuclear) submarines "are designed for anti-ship/anti-submarine role" (MoD). (<http://www.royal-navy.mod.uk/static/pages/178.html>)
- SSBN (Ship Submersible Ballistic Nuclear) submarines "are designed to maintain the strategic deterrent" (MoD). These are Resolution class and Vanguard class. (<http://www.royal-navy.mod.uk/static/pages/146.html>)

Nuclear-powered submarines in other countries

We understand that there are approximately 360 nuclear-powered submarines in the world. The MoD state that:

- the USA has - estimated 72 in service and 4 being built
- Russia has - estimated 48 in service and 3 being built
- China has - estimated 5 in service and 5 being built
- France has - 10 in service. The rest of their submarines are apparently no longer in service.

What do other countries do with the radioactive waste? The MoD state that:

- The USA disposes of the separated Reactor Compartments at Hanford Reservation in Washington State (see the information on options for storage/disposal).
- France has removed the Reactor Compartment of La Redoubtable
- Russia - various
- China - not known

The UK Nuclear Waste Classification System

The following are the UK classifications of radioactive waste.

The Reactor Compartment and associated pipe work of nuclear-powered submarines are classified as Intermediate, Low and Very Low Level wastes.

VERY LOW LEVEL WASTE (VLLW)

Examples: Wastes arise from a variety of sources, including the non-nuclear industry.

Danger/Safety: VLLW contains very low levels of radioactivity and, under current regulation, requires no special protective measures.

Disposal/Storage: These wastes are sent to landfill, incinerated, or may be contained in domestic refuse. The method of disposal depends on the nature and quantity of the material.

LOW LEVEL WASTE (LLW)

Examples: LLW consists mainly of items such as protective clothing, laboratory equipment and site equipment which have come into contact with radioactive material.

Danger/Safety: LLW requires containment to protect the operator but (under current guidance procedures) does not normally require radiation shielding.

Disposal/Storage: Since 1959, most of the UK solid LLW has been disposed of at the site operated by BNFL at Drigg, south of Sellafield in Cumbria, or at Dounreay in the north of Scotland.

Definition: LLW is defined as waste with a radioactive content that does not exceed 4 GBq/tonne of alpha activity or 12 GBq/tonne of beta/gamma activity.

INTERMEDIATE LEVEL WASTE (ILW)

Examples: ILW consists principally of materials that have been irradiated in a nuclear reactor (e.g some RPV internal components), equipment that has been used in the processing of radioactive materials, and chemical residues.

Danger/Safety: ILW requires radiation shielding and/or containment during transport and storage/disposal in order to protect the operator and the public.

Disposal/Storage: No disposal route is currently available for ILW and at present most of these wastes are stored at the sites where they are produced. Some minor waste producers make use of the UK Atomic Energy Authority's ILW store at Harwell.

Definition: ILW is classified as the range of radioactive waste whose radioactive content exceeds the upper limits for LLW but that does not require heat to be removed during storage.

HIGH LEVEL WASTE (HLW)

Examples: HLW consists mainly of the liquid waste produced from the reprocessing of nuclear fuels. (This is the residue from the primary stages of the separation of uranium and plutonium from irradiated nuclear fuel.) The liquid HLW is often made into a solid glass HLW, through a process called "vitrification". Plant equipment from the vitrification process that has been contaminated with the HLW is also categorised as HLW.

Danger/Safety: HLW requires radiation shielding and containment.

Disposal/Storage: HLW can have considerable heat output, which has to be taken into account in the design of processing, storage and disposal facilities.

Note: there is no HLW in the Decommissioned Nuclear Submarines, as the spent fuel has been removed.

Radioactive materials in the Reactor Compartment

The most radioactive parts of the Reactor Compartment are components within the Reactor Pressure Vessel (RPV) which hold the nuclear fuel rods.

However, other parts of the Reactor Compartment are less shielded than the Reactor Pressure Vessel (RPV). The MoD state that the largest contributor to the radiation levels within the Reactor Compartment is actually the CRUD that has collected on the insides of the pipes around the RPV. This is how the MoD describe it:

"corrosion and wear products transported by the primary coolant become irradiated during their passage through the core. These particles plate out on system internals to form a fine film of radioactive CRUD, the primary radioactive constituent of which is Cobalt 60. This isotope produces hard gamma emissions and its biological hazard is exacerbated by the fact that, because much of the CRUD is deposited outside the RPV, the high energy emissions from the Cobalt 60 are not attenuated by the RPV's significant biological shield. This lack of shielding means that the CRUD is by far the largest contributor to the Average Radiation Level (ARL) within the Reactor Compartment." (From paragraph 1 of Annex E of "The ISOLUS Investigation")

The MoD state that the dominant radioactive materials in this CRUD are Cobalt 60, Iron 55 and Nickel 63. The first two of these have half-lives³ of 5.3 and 2.7 years. This is a strong reason for keeping the Reactor Compartment intact, at least until most of this radioactivity has decayed. Keeping the Reactor Compartment stored intact (the MoD suggest for 60 years) would reduce the doses of radiation received by workers involved in any subsequent cutting action. It would also reduce contamination to the environment. When the Cobalt 60 and Iron 55 have decayed, the remaining Nickel 63 and Nickel 59 then become the dominant radioactive materials. (*Annex E of "The ISOLUS Investigation"*).

Brief history of MoD policy & options on the disposal/storage of nuclear waste

A brief history (compiled from 'The ISOLUS Investigation,' Annex B)

1970s: Sea dumping had been used continuously for the disposal of Intermediate Level Waste (ILW) since the 1950s. The MoD's strategy for the disposal of nuclear submarines was similarly to dispose of these at sea, after defuelling.

1972: The London Dumping Convention voted to suspend sea dumping of radioactive wastes until such time as scientific studies into the environmental effects had been completed. (This did not prevent emissions from nuclear facilities). The UK Government and MoD took the view that this vote was not binding. The MoD's preferred policy remained sea disposal.

³ What is a 'half-life'?

Radioactive substances decay into new substances known as decay products. The 'half-life' of a radioactive substance is the time taken for half of it to decay into the decay product. When the radioactive substance decays it gives out radiation. Sometimes the decay product is itself radioactive and will decay further giving out radiation.

For example, the half-life of 'Cobalt-60' is 5.24 years. This means that every 5.24 years the amount of Cobalt-60 will halve. For example, if we start with 8 kilograms of Cobalt-60, after 5.24 years there will be 4 kilograms of Cobalt-60 and after a further 5.24 years there will be 2 kilograms and so on. When Cobalt-60 decays it changes into Nickel-60, which is a stable substance. Nickel-60 does not decay further and so does not give out radiation.

In the MoD document and elsewhere you will see the half-life written as $T_{1/2} =$ '. For example, the half-life of Cobalt-60 is written $T_{1/2} = 5.24$ years.

Half-lives vary enormously. For example, Iron 55 (Fe 55) has a half-life of 2.7 years. Yet the half-life of Nickel-59 (Ni-59) is 76,000 years. The radioactivity of some of these substances can therefore reduce substantially over years, or over decades, but it can also be around for a very long time, depending on which isotopes are present. (Like Cobalt-60, Iron-55 and Nickel-59 decay into stable isotopes.)

It is the activity (energy) of the isotopes which determines the length of the half-life. High energy isotopes decay more quickly (and thus have shorter half-lives), but release more activity and are therefore more radioactive.

1982: The MoD went ahead with organising the dumping at sea of Intermediate Level Wastes. However, action by the National Union of Seamen (supported by environmental pressure groups) "ensured that the 1982 dump did not take place" (Annex B §5). This also resulted in further sea dumping of radioactive waste being suspended.

1984: A nationwide public consultation in the USA revealed strong public opposition to sea dumping. The US Navy decided to proceed with disposal of the reactors by land burial in arid land at Hanford in Washington State (north-western USA). So far over 70 submarine Reactor Compartments (RC's) have been taken there.

Mid-80s: Finding a site for land disposal had proved a problem. NIREX (Nuclear Industry Radioactive Waste Executive - the body responsible for finding a way of disposing of civil nuclear waste in the UK) initially made it clear that they were not considering space for large items like Reactor Compartments (Annex B §13).

The Secretary of State for the Environment ruled that Intermediate Level Wastes would be stored in an underground Deep Waste Repository.

1993: The dumping of nuclear-powered submarines at sea was finally ruled out by amendments to the 1972 London Dumping Convention (adopted in 1993) which prohibit the dumping at sea of radioactive material.

1990s: The MoD policy was for temporary storage afloat at Devonport and Rosyth. This anticipated final disposal in an underground Deep Waste Repository, but kept open the possibility of disposal at sea (Annex B §24).

Land owned by the MoD was also investigated for possible sites for land disposal or storage (Annex B §14, 22).

1997: The NIREX proposal for an underground 'laboratory' in west Cumbria (to prepare for a National Deep Waste Repository) was rejected. Such a site for the land burial of Intermediate Level Wastes is not now expected until at least 2050, if at all.

The MoD was criticised by the Radioactive Waste Management Advisory Committee (RWMAC) as being seen to have 'no policy' on the future of decommissioned nuclear-powered submarines. These criticisms have also been supported by increased attention in the media and from people who live in the urban areas around the dockyards.

The current situation

- A National Radioactive Waste Management Facility is now not expected until at least 2050; the UK Government is currently in the early stages of a process intended to decide on the long-term management of radioactive wastes. The ISOLUS proposals are designed on the assumption that a National Facility will be available in the longer term.
- Full capacity of existing practicable storage areas in Devonport and Rosyth will be reached by 2012.
- By 2040 there will be a total of 27 decommissioned nuclear submarines for which to find a long-term solution.
- Project ISOLUS is committed to finding the best solution for the interim storage of any Intermediate Level Waste and the final disposal of any Low Level Waste resulting from the disposal of decommissioned nuclear submarines until such time as a national facility becomes available.

- In February 2003 private industry was invited to submit outline proposals for the work. Five outline proposals have been received.

Disposal or Storage

This is a summary and guide to some of the information set out in the MoD/WSA report – ‘The ISOLUS Investigation’

Dispose of the submarines at sea?

"Sea dumping remained the MoD's preferred option until the 1993 London Dumping Convention finally ruled it out. The MoD spent a considerable amount of time and resources attempting to prove that sea dumping of the entire submarine was the best option, technically and in terms of environmental impact and dose accrued by the work-force" ('The ISOLUS Investigation,' Annex B §12).

It is extremely unlikely that sea disposal could be resumed.

Dispose of the Reactor Compartments on land?

To bury the waste underground would require burial chambers large enough to accommodate 27 Reactor Compartments (which are each the size of 2 double-decker buses), or it would require cutting up the Reactor Compartment into smaller units (Annex B §11, 13). Cutting up the Reactor Compartment would involve exposing workers and the environment to radioactive contamination (Annex B §16).

This exposure might be reduced if the Reactor Compartment was first stored for 60 years because some of the radioactivity would decay (see The decay of radioactivity in the Reactor Compartment, below, or Annex E of ‘The ISOLUS Investigation’).

As plans for building a National Radioactive Waste Repository are currently being reconsidered, and no repository is expected to be in place by 2050 at the earliest, the radioactive wastes from decommissioned submarines will need to be stored for an indefinite interim period.

Key Conclusion 1 of the MoD report is that "The interim storage strategy for laid-up submarines should not be dependent on realisation of a national Deep Waste Repository" ('The ISOLUS Investigation,' §108).

For this reason, the MoD refer to "planning for indefinite storage" and identify the need for "an interim storage strategy which is flexible enough to & store and monitor for the foreseeable future" ('The ISOLUS Investigation,' §52-53).

Some of the advantages of storage over disposal

'Storage' of radioactive wastes means that they can be retrieved. 'Disposal' of radioactive wastes is permanent and not intended to be reversible. Disposal repositories are designed so that wastes cannot be retrieved after the repository is closed.

The MoD ISOLUS Investigation (Annex B) suggests that storage has certain advantages over disposal:

1. "The Reactor Compartment is retrievable - this is popular in the Nuclear Industry/Environmentalist world because it means that if the rules or circumstances change, it would be possible to deal with the package in whichever

way was considered more appropriate. From the Environmentalist point of view it would also remain a constant reminder of the burden caused by the Nuclear Industry."

2. "The Reactor Compartment can be monitored and maintained as deemed appropriate, and these checks can be witnessed and confirmed by independent assessors, so reinforcing public confidence."
3. "Final disposal costs are delayed allowing financial benefits in terms of discounting the future provision."
4. "Benefits could be gained as a consequence of the technological advances in remote handling, which could considerably reduce the radiation dose burden, received during the final disposal process."
5. "In storing the Reactor Compartment, both the quantity of ILW (Intermediate Level Waste) and the level of radioactivity within the compartment would reduce due to the natural decay of radioactive isotopes."

Storage Options

This is a summary and guide to some of the information set out in the MoD/WSA report - **ISOLUS Investigation**

Store the submarines on the sea bed?

Because of the controls set out by the London Dumping Convention it would only be possible to store the submarines on the sea bed within UK inshore waters. The only possible site would have been between the Scottish mainland and the Outer Hebrides. Recovering it would be expensive. The MoD state that this proposal has been rejected (The **ISOLUS Investigation**, Annex B §21).

Store the submarines afloat?

This is the current policy - submarines are stored at the Naval Bases of Rosyth and Devonport. However, existing practicable space in the docks will run out in 2012, and laid-up submarines cannot be kept afloat indefinitely. Providing more space for afloat storage will be expensive, as will continued maintenance, especially after a submarine has been stored afloat for 30 years. There is also concern and criticism by local people living in the urban areas around the docks.

Key Conclusion 2 of 'The ISOLUS Investigation' states that "Afloat storage should be regarded only as a stop-gap measure pending the development of an alternative strategy for interim storage".

The submarines laid-up at these ports still require maintenance dockings every 12 years. The cost of storage afloat therefore increases the more any subsequent method of storage is delayed.

Store the submarines on land?

To store the whole submarine on land is dismissed by the SSA/MoD as non-viable ('The ISOLUS Investigation,' §7), due to the size of the submarines and the difficulties of moving them.

Store the radioactive wastes on land?

The alternative is to separate the Reactor Compartments and associated pipework, store them, and recycle the other parts of the submarines.

Cut up the Reactor Compartments?

One possibility is to then cut up the Reactor Compartments and package the radioactive wastes in containers to reduce the storage space needed and to make them transportable over land. However, this has the potential to expose workers to increased levels of radiation and an increased risk of contamination of the Environment. It also increases the amount of LLW & ILW that would require disposal now.

Cutting up the Reactor Compartments and packaging the wastes for storage means that the wastes remain retrievable. Some potential future options (perhaps options that have not yet been thought of), though, may not be possible if the Reactor Compartment has already been cut up.

Store the Reactor Compartment intact?

The alternative is to keep the Reactor Compartment intact, for the short term(30-60 years) then subsequently cut up for disposal when the ILW National facility comes on line. This would reduce the risks of radioactive exposure and contamination, and would mean that no future options had been closed off (§88). Moving the Reactor Compartments to a storage site is difficult, though, as they are the size of 2 double-decker buses, and weigh 750 tonnes.

Disposing of the Reactor Compartments intact is the approach adopted by the USA. Reactor Compartments are buried permanently at Hanford in Washington State (north-western USA). So far around 70 submarine Reactor Compartments have been taken to Hanford. Permanent burial of reactor compartments in the UK is not possible due to the Geological and meteorological conditions.

‘The ISOLUS Investigation’ suggests that storage of the intact Reactor Compartment for up to 60 years would optimise the benefits from the decay of radioactivity in the Reactor Compartment (‘The ISOLUS Investigation,’ §107, 56-58).

Storage of the intact Reactor Compartment also means that the various radioactive wastes can be retrieved or stored differently in the future, if technology and understanding develop.

Something else?

You may consider these storage options to be adequate or inadequate. You may have, or know of, other options, and/or want other options to be considered.

Sites

Siting issues were considered in the Isolus Front End Consultation. With regard to siting issues, the Final Report made the following recommendations:

32. A site with existing, relatively large scale, nuclear activity should be used, unless there are strong and clearly justified reasons otherwise.
33. Geological stability and the implications of climate change need to be assessed in relation to the site(s) used for storing the wastes.

34. The wastes should be stored in a site where unauthorised access is prevented.
35. The possibility of storing the wastes at more than one site should not be discounted
36. The MoD should be explicit about the potential for expansion of storage beyond the existing 27 submarines, and should clarify, as far as is possible, what this potential could imply for the storage site(s)
37. The MoD should be explicit about the responsibility, location and management of the waste beyond the initial 30 year period, and clarify, as far as is possible, the implications for the storage site(s).
38. Transport of the wastes should be minimised, and should avoid centres of population, subject to other considerations, unless there are strong and publicly acceptable reasons otherwise. Transport by sea is preferable.
40. When assessing proposals, consideration should be given to the availability of suitable expertise in both the geographical area and the relevant areas of knowledge and experience, and for how this expertise will be maintained over time

What siting proposals does the MoD consider in ‘The ISOLUS Investigation’?

The MoD **ISOLUS Investigation** is, as it says, a review of options rather than of sites. The WSA state that the debate is still open on both issues. However, when considering the options, the report does mention actual sites on three occasions. (See Annex g, which considers the issues associated with various sites).

Storage afloat:

The report says "Berthing in 4 Basin at Devonport (in Plymouth) is the favoured option if the afloat storage policy is required to continue after 2012, and it is noted that preliminary action has been taken already at Devonport to this effect. This basin has the capacity to store a further 11 vessels which will provide storage space until 2037." (§70) It has 4 laid-up vessels already.

Storage on land:

The report mentions two potential land storage sites for storing the Reactor Compartments. These are Rosyth near Edinburgh and Devonport in Plymouth. These are the two dockyards where nuclear fuel rods are currently taken out of the submarines (before being transported by train to Sellafield in Cumbria).

Rosyth: The report says

"It should be possible, within the BRDL (Babcock Rosyth Dockyard Ltd) estate, to make land-storage space available for the separated Reactor Compartments of the seven redundant submarines currently berthed at Rosyth." (§92a).

This links to a footnote which says "However, BRDL is understood not to support this way forward, preferring their own proposal."

Devonport: The report says simply:

"Although there is no obvious land store site within the DML (Devonport Management Ltd) estate, it would be advantageous if a limited or temporary site could be found in order that the land store programme in Devonport could commence as soon as possible."

The only mention of siting within the conclusions of the report is that "Land Storage of separated Reactor Compartments is an attractive option but further work is needed to narrow the site options and develop the strategy" (§111).

Finance Issues

A Private Finance Initiative (PFI) is a form of Public-Private Partnership (PPP). PFI involves public sector organisations (such as the MoD) commissioning a private contractor to provide a *service* for an agreed period of time. This may involve the private sector contractor in building a facility (e.g., a waste store). The private contractor takes responsibility for the required capital investment and is paid by the public sector organisation over the entire period of the contract. In effect the public sector organisation *leases* the service from the contractor. Typically, but not necessarily, a PFI arrangement involves the contractor borrowing capital from a third party financial institution. MoD policy demands that all projects considering PFI need to develop a "public sector comparator," to show the cost of meeting the requirement by non-PFI means.

The government's Trade Partners UK website gives the following basic explanation of Public-Private Partnerships:

PPPs are an increasingly popular method of developing infrastructure and modernising services based upon a partnership between the public and private sectors. The attraction of forming such partnerships lies in the ability to mobilise more capital than that purely held in the public account and to use private sector expertise to help manage project expenditure more efficiently. Governments can bring private sector into the modernisation and management of projects, while remaining responsible for public interest issues and ensuring delivery at specified service levels. In short, PPPs enable governments to meet demands for the development of modern and efficient services and provide value for taxpayers.

The following sections are adapted from the MoD's Acquisition Management webpages:

Public Private Partnership (PPP) is one of the central strands of the Government's strategy to modernise public services under the Better Quality Services initiative. The PPP programme encompasses a number of initiatives such as the Private Finance Initiative (PFI), Partnering, the Wider Markets Initiative and Outsourcing. PFI is at the core of the PPP programme and can involve the private sector in creating (or buying) a new physical asset and the selling of a range of services to the Department built round the asset over an agreed period of time.

MOD Ministers have endorsed the use of PFI to provide services throughout the Department. Only if PFI has been demonstrated to be unworkable, inappropriate or uneconomic should projects consider using the MOD's own capital funding resources.

PFI

PFI aims to provide better value for money by allowing MOD to focus on its core tasks, while benefiting from additional capital investment. PFI offers the potential for greater risk transfer (including demand, construction and residual value risk) to the private sector, and is likely to involve rigorous due diligence scrutiny of the project by

banks. PFI allows the private sector the opportunity to show innovation in the method of service delivery and places strong incentives on the contractor to deliver the service to time, cost and performance targets, as well as affording scope for the generation of 3rd party revenue.

PFI involves contracting for a service, with service-based payment mechanisms, where substantial capital investment is needed in an asset essential to deliver that service.

Partnering

Partnering is essentially the development of new, much more co-operative long term relationships between MOD and industry. Partnering differs from conventional contracting relationships in that effective communication strategies amongst partners leads to trust, better and earlier identification and hence management of project risks, and increasing better value for money being gained in large scale complex requirements.

PPP Projects

For all types of PPP customer awareness and understanding needs to go beyond pure technical knowledge. Management structures and incentives at all levels need to be established such that the relationship is constructive and predisposed to solve problems. Nevertheless, there is no substitute for a clear and robust contract that specifies outputs, risk apportionment, and processes for change and dispute management.

For a PFI project, MOD should specify its needs in output terms, based on the required capability rather than a pre-determined technical solution. Bidders will then have the maximum possible flexibility to adopt innovative approaches or introduce practices from other sectors of industry. The procurement process for a PFI project can be a substantial task for both the MOD and bidders, with a consequent need for adequate resources. PFI is demanding but has realised savings of up to 40% in forecast costs compared with other forms of procurement.

The following are broad indicators of the scope for PFI in a project:

- A requirement for significant capital investment now or in the future;
- A substantial element in the requirement can be configured as a service;
- Scope for innovation in the delivery of the service;
- MOD risks which could be better managed in the private sector;
- Scope for long term contracts.

Projects with scope for third party revenue or for the transfer of demand risk to the private sector particularly suggest themselves for PFI, but these are not mandatory requirements for a PFI deal.

Projects need to be aware of a number of features that differ from other procurement approaches:

- The need to develop a public sector comparator, representing the cost of meeting the requirement by non-PFI means;
- Consultation with the Trades Unions, as any deal is likely to have an impact on civilian staff given Transfer of Undertaking (Protection of Employment) (TUPE) requirements;
- The impact of European Union procurement directives;

- The use of the negotiated procedure and pre-qualification questionnaires (PPQs);
- A close MOD/contractor relationship during the in-service phase;
- The need for additional skills and expertise which may not be found in MOD.
- The probable involvement of banks and finance houses in the negotiation of the deal.

PFI will not always be the answer and should only be considered where there is scope to achieve greater value for money than by conventional procurement. To minimise the possibility of expending unnecessary resource investigating PFI for inappropriate projects, and to maximise the chances of extracting best value for money in projects that pursue PFI, it is very important to seek advice at the earliest stages of a project. The DPA Private Finance Group (for DPA projects), the DLO PPPG (for DLO projects) or other local Private Finance Units are the first points of contact for advice and support. The PPP Unit in MOD HQ considers wider PPP policy and becomes involved in large and novel projects.

Storing, packaging and cutting up nuclear reactors

The text in this section was written by the MoD

PROJECT ISOLUS

Project ISOLUS Interim Storage Of Laid Up Submarines is tasked with resolving the issues regarding the interim storage of the Intermediate Level Waste (ILW) which results from operation of nuclear powered submarines. The project was commissioned as the present afloat storage policy was judged to be unsatisfactory and the present afloat storage facilities would be full by 2012. The start point for this project is a decommissioned, de-equipped, defuelled, previously nuclear powered submarine which has been prepared for prolonged storage afloat, (DDL P). The end point for the project is the decommissioning of any facilities used in the preparation and interim storage of the ILW and subsequent transfer and storage of the remaining ILW to the National Intermediate Level Waste Facility, when it becomes available.

Storage of Separated Reactor Compartments (RC's)

Figure 1. Both the Americans and the French have adopted similar options for the disposal of their nuclear submarines; however, in these cases the separated RC's are seen as a final disposal route and not as an interim storage solution, as is the UK's intention. Furthermore, RC separation before interim storage is broadly in-line with the civil nuclear industries decommissioning policy of 'Safe Store'.

The separation of the RC would pose no technical problems as it would utilise cutting techniques available in commercial shipbuilding and refitting. The submarine would be docked down, front and rear sections of the hull removed. With no requirement for significant work inside the RC it would only require bulkheads or canning plates to be fitted at either end to ensure that containment is maintained throughout the land storage period. A cradle could be fitted to the underside to facilitate transport and support at the final storage site.

Provided that a RC is separated soon after de-fuelling operations, there will be no further requirement to conduct a full DDLP package and, if the land storage period is sufficiently long to allow for radioactive decay before final dismantling, aggressive decontamination of the primary circuit would not be required.

Once prepared for land storage, the RCs could be transported, either by sea or land, (most likely by sea due to the size) to suitable storage locations where they would be placed in simple weatherproof buildings capable of providing a degree of containment. This option then requires the RC to be cut up and packaged, as described latter, at some future point in time when the National Intermediate Level Waste Facility becomes available.

Storage of Primary Plant Components as Unpackaged ILW

An alternative to the storage of separated RCs would be the dismantling of the reactor plant and the storage of the major activated structural components, such as the RPV, Figure 2. before complete break-up and disposal of the hull structure and remaining reactor plant systems as ILW, LLW or free release material.

This strategy would require the decontamination of the primary circuit otherwise there is a possibility of high worker dose rates and potential release of CRUD deposits. If the decontamination is sufficiently aggressive, it may reduce the majority of primary plant components (SGs, Main Coolant Pumps, pipework etc.) to LLW, or even free release material, confining the majority of ILW to the RPV and PST.



Civil PWR RPV being lifted.

After docking down the submarine would be cut up with the RPV being removed and placed in a shielded transport container. It is believed that all remaining ILW would fit within a second “4 metre”. shielded container for subsequent transport and storage. Although this strategy does not pose any real technical challenge, radiation dose rates inside the RC, especially in the areas surrounding the RPV, will be higher than if a period of optimum storage had been completed before final break-up. Preliminary analysis of the doses received during these operations has shown them to be well within acceptable limits.

A purpose built ILW store would be required to house the remaining ILW and the RPV package, which due to its higher level of activation, is likely to require additional shielding. However the visual impact of such a facility would be considerably less than one for the storage of separated RCs. Transportation of the

ILW to the Interim storage site and subsequently to the National Intermediate Level Waste Facility would also be significantly easier than for separated RC's.

Storage of Primary Plant Components as Packaged ILW

This strategy is similar to that of the Storage of Un-packaged ILW described previously, but further dismantling of the RPV would be required to be carried out in a purpose built ILW processing facility on site. This would allow the waste to be packaged into NIREX '4-metre' storage boxes, Figure 3, for storage in an on site ILW store, prior to final disposal when the National Intermediate Level Waste Facility becomes available.

This strategy is seen to be technically viable providing that the primary circuit has been decontaminated. The cutting-up of highly activated RPV/PST structures will be dose intensive for the workers involved, but predicted to be well within acceptable limits. To help address these ALARP issues, it is likely that the cutting up of the RPV/PST structures will take place underwater using remote underwater cutting techniques that have been already proven on civilian PWR.

The strategy for the storage of packaged ILW results in the completion of the disposal work and is not reliant on the availability of a National Intermediate Level Waste Facility.