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Science and Technology Committee Publications

Science and Technology - Third Report

Here you can browse the report which was ordered by the House of Lords to be printed 10 March 1999.

CONTENTS

REFERENCES TO EVIDENCE

The written and oral evidence received by the Committee is published separately in two volumes:

Written evidence received up to 30 January 1998 is published in HL Paper 89 of Session 1997-98.

Evidence received from 1 February 1998, including all oral evidence, is published in HL Paper 26 of Session 1998-99.

Q refers to a question in oral evidence;

p refers to a page of written evidence printed in HL Paper 89, Session 1997-98;

P refers to a page of written evidence printed in a separate volume HL Paper 26, Session 1998-99.

Correction

HL Paper 26, Session 1998-99, page 383. The Memorandum for Synroc International Limited was submitted by Mr Brian Frey.

Select Committee on Science and Technology Third Report

THIRD REPORT

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10 March 1999

By the Select Committee appointed to consider Science and Technology.

Ordered to Report

Management of Nuclear Waste

EXECUTIVE SUMMARY

1. With the rejection in 1997 of the Nirex planning application for a rock characterisation facility at Sellafield, as a step towards the development of a deep repository, the United Kingdom was left with no practical plan for the disposal of most of its nuclear waste. This prompted the Committee to enquire into the management of nuclear waste in the United Kingdom.
2. The bulk of nuclear waste that exists now and is certain to arise in future originates from past military and civil nuclear programmes. The problem exists and has to be solved. It could not be avoided by deciding today to discontinue nuclear power production or the reprocessing of spent fuel (Chapter 2).
3. A dominant characteristic of much nuclear waste is the period of hundreds of thousands of years over which it must be effectively isolated from people and the environment. This poses problems of technical assurance and public acceptance in a field which is unique in its demands (Chapter 2).
4. The long time-scales involved might be thought to be a reason for postponing decisions. The contrary is the case, since existing storage arrangements have a limited life and will require replacement, and eventually the repackaging and transfer of stored waste. Reliance on supervision for very long periods increases the probability of human error (Chapter 3).
5. We received a great deal of evidence on the technical issues and conclude that phased disposal in a deep repository is feasible and desirable. This view is shared by the authorities in other major nuclear nations facing the same problems and by the international agencies dealing with nuclear waste. The phased approach which we recommend would allow decisions to be taken in a considered way as technical confidence and experience develop, and would avoid premature decisions which may be difficult to reverse (Chapter 4).
6. The future policy for nuclear waste management will require public acceptance. We examined ways in which this is being approached in other countries and we considered means to achieve it in the UK. Central to this is the need for widespread public consultation before a policy is settled by Government and presented to Parliament for endorsement. We believe that our report will provide a

useful input to such a consultation process. We draw attention to the further need to secure local acceptance of a recognised national need and we suggest some ways of achieving this (Chapter 5).

7. Present policy for nuclear waste management is fragmented. There are wastes for which no long term management option has yet been decided and there are a number of significant materials, for which no use is foreseen, which are not categorised as waste at all. This leads to uncertainties in the planning of future facilities and to the continued storage of hazardous materials in an essentially temporary state. Until the fate of these materials is settled, and the capacity of potential sites is identified and explored, it will not be possible to know whether one deep repository will suffice. In the case of plutonium we draw attention to the large and growing stock level and recommend the excess over foreseeable need be declared as waste (Chapter 7).
8. These problems require changes in the present organisational structure for nuclear waste management. We recommend the establishment of a new body, a "Nuclear Waste Management Commission", charged with the development of a comprehensive strategy. This should be done through public consultation, with the object of defining a widely acceptable solution. If, as we recommend, phased geological disposal is adopted, there will be a need for a "Radioactive Waste Disposal Company" with the remit to design, construct, operate and eventually close the repository (or repositories). When these two organisations are established they will subsume the roles of Nirex and RWMAC. We believe it to be essential that Government takes a positive role in the development and implementation of such a strategy, and that Parliament endorses the strategy and renews its support regularly during implementation (Chapter 6).
9. The problem is one for which no precedent exists. It requires a determined effort on the part of Government and the public to arrive at a solution without unnecessary delay—a solution which leaves a clear and manageable situation and protects future generations and their environment.

CHAPTER 1: INTRODUCTION

1.1 On 17 March 1997, the Secretary of State for the Environment upheld Cumbria County Council's refusal to grant Nirex planning permission for a Rock Characterisation Facility (RCF) at Sellafield. This "stopped dead in its tracks the search for a long-term disposal route for intermediate level radioactive waste" (POST Report 106)[1]. Since the 1976 report by the Royal Commission on Environmental Pollution (RCEP)[2], it has been Government policy to pursue the disposal of solid radioactive waste as the long-term solution to nuclear waste management problems. The purpose of our enquiry was to see where the rejection of the RCF planning application left that policy for the future management of radioactive wastes in the United Kingdom.

BACKGROUND

1.2 In 1976 the RCEP[3] stated, "there should be no commitment to a large programme of nuclear fission power until it has been demonstrated beyond reasonable doubt that a method exists to ensure the safe containment of long-lived highly radioactive waste for the indefinite future". The report continued, "We are clear that the responsibility for developing the best strategy for dealing with radioactive waste is one for the Government, and specifically for a department concerned to protect the environment". It recommended a statutory body, the Nuclear Waste Management Advisory Committee, to advise the Secretary of State. It also recommended an executive organisation to develop and manage the radioactive waste disposal facilities, the Nuclear Waste Disposal Corporation. This latter body would meet the cost of rendering wastes environmentally acceptable through charges levied on the nuclear industry. The Royal Commission concluded its discussion on nuclear waste with the words, "Radioactive waste management is a profoundly serious issue…There must be a clear, identifiable, policy centre and a means to ensure that the issues posed by waste management are fully considered at the outset of a nuclear programme, not dealt with many years after the decisions on developments that lead to the waste have been made and when options may have been effectively foreclosed".

1.3 Following the RCEP report, in 1978 the Government set up the Radioactive Waste Management Advisory Committee (RWMAC). In 1982 it established the Nuclear Industry Radioactive Waste Management Executive, which in 1985 became UK Nirex Ltd. Neither it nor RWMAC were the organisations envisaged by the RCEP report. In 1991, after several years of site evaluation and no little public controversy, Nirex selected Sellafield as its preferred option for the site of a deep repository for the disposal of radioactive waste. Nirex considered that a precursor of any such disposal facility should be the construction of a RCF to investigate in detail the conditions in the vicinity and to establish whether they were suitable. It was the planning permission for the construction of this research facility which was refused in 1997.

1.4 Between the report of 1976 and the events of 1997 waste management issues have been the subject of much study. One of the more recent reports is the Royal Society's "Disposal of Radioactive Wastes in Deep Repositories (November 1994). Prophetically, in the first of its principal recommendations, which dealt with the early stage of development of the science, was a warning that "the first exposure to alternative interpretations and to the inadequacies of supporting data could come in the confrontational climate of a public inquiry. This could set back the entire programme, with serious consequences for the achievement of satisfactory solutions to the problems of radioactive waste management and disposal in the UK". The report went on to argue the need for transparency and openness with data, an issue which has also been significant in our own enquiry. The Royal Society's latest report on nuclear issues, Management of Separated Plutonium, came out in February 1998 after the commencement of our enquiry. Again, this has been influential in our proceedings because the continuing production and storage of plutonium could have long-term implications for the United Kingdom's management strategy for nuclear waste. The House of Lords Select Committee on the European Communities report, Radioactive Waste Management, in 1988[4] identified the issues of public confidence and public acceptability as keys to future progress. It recommended that deep geological disposal be pursued with determination. "No better solution is discernible and it is impossible to wait any longer for some hoped-for unspecified alternative" (para 210). These reports, together with many others including in particular the POST Report published at the commencement of our enquiry and the many constructive reports produced before that by RWMAC, have all contributed greatly to our work.

1.5 Notwithstanding the many reports published in the intervening years, radioactive waste management is no less a profoundly serious issue now than it was when examined by the RCEP in 1976. Much time has been allowed to pass, many recommendations have not been acted upon, and more waste has been, and is still being, created. There is therefore a large legacy of existing waste that present a serious challenge. This is a major problem that has been dealt with in an ad hoc way for decades. Currently, delays in finding a long-term solution mean that new waste stores, intended as a temporary measure pending construction of a permanent facility, are having to be built. If the delays continue, even more will be needed and some existing stores will need to be replaced. In November 1998, towards the conclusion of our enquiry, the Health and Safety Executive published a report[5] which identified some current waste management issues. Our enquiry is not primarily concerned with issues affecting the safety of stored wastes but the HSE report serves to highlight the need for a coherent waste management strategy. Overall, from the standpoint of immediate safety, the present situation is under control, but the size of the task ahead and the time-scale of any foreseeable solution make a political decision on future strategy a matter of urgency.

This Report

1.6 Our report is divided into four parts. The first describes the present situation, giving some of the history and background to the current wastes in the United Kingdom's inventory. This part also outlines some of the ways of dealing with nuclear waste that have been used in the past or advocated to us. In the second part we analyse the options for waste management in the UK from the technical perspective, reaching conclusions on the preferred method. We then look more closely at the constraints on implementing this waste management strategy, in particular the question of public acceptability. We conclude this part with a review of policy and make recommendations for the future. In the third part we consider related but separate waste management issues, particularly reprocessing of spent nuclear fuel and the stock of plutonium. The report concludes with a summary of our recommendations.

1.7 A general introduction to radioactivity, nuclear fission and the problems they pose is given in Box 1. The membership of the Sub-Committee which produced this report is listed in Appendix 1 and the Call for Evidence we issued is set out in Appendix 2. The Enquiry was based on the assistance of a wide range of individuals and organisations who responded to the Call for Evidence: these are listed in Appendix 3. We are most grateful to them all for their time and effort. We also wish to express our thanks to those whom we visited, who made presentations or provided briefing: in particular British Nuclear Fuels plc (BNFL) Sellafield; the UKAEA, Dounreay; and the many people who were so generous with their time and hospitality during our visits to the US, Canada, Sweden and France (see Appendix 4). Thanks go also to the staff of the High Commission in Canada and Embassies in the other countries for their assistance with our overseas visits. Particular thanks go to our Specialist Adviser, Ms Marion Hill of W S Atkins, without whose experience, expertise, and all manner of assistance, the production of this report would have been immeasurably more difficult. We very much appreciate her help and that of everybody who has contributed to this Enquiry.

1.8 A glossary of terms and acronyms is in Appendix 5.

Box 1: An introduction to radioactivity

The nature of radioactivity

The nucleus of an atom may be considered to contain neutrons and protons, the number of which is called the atomic number. Radioactivity originates from the nuclei of atoms that are unstable because they contain too few or too many neutrons. In order to attain stability, these 'radionuclides' spontaneously eject nuclear matter (radiation) as either alpha-particles (nuclei of helium atoms), beta-particles (electrons), gamma-rays (electromagnetic radiation), or neutrons. The eventual result is that unstable atoms transform themselves into more stable atoms of the same or other elements. For example, when the naturally occurring radionuclide samarium-147 (with atomic number 147) ejects an alpha-particle (with atomic number 4), unstable samarium atoms are transformed into stable atoms of neodymium-143.

The transformation illustrated above is the process of radioactivity. In some cases (samarium-147 is an example) a radioactive 'parent' nuclide decays to a stable 'daughter' product. For the heavier radionuclides, however, a chain of daughter products may be involved, only the last of which will be stable. For example, in the naturally occurring uranium chain the parent is uranium-238, the radioactive daughter products include uranium-234, thorium-230, radium-226, lead-210 and polonium-210, and the end of the chain is a stable form of lead. The decay pattern of a single radionuclide is exponential with time, is characteristic of the particular radionuclide, and is precisely known.

A useful measure of the decay rate of a radionuclide is the 'half-life', which is the time taken for half the atoms in a sample of that radionuclide to transform themselves. For a given radionuclide, activity and half-life are inversely proportional. The more active the radionuclide, the shorter the half-life, so the faster the decay. After a sufficient time has passed, almost all of a radioactive sample will have decayed to stable products and be no longer radioactive. That time, however, may be very long, perhaps millions of years or more if the half-life is large enough, and in that case the radioactivity will be correspondingly weak.

For example, the radionuclide krypton-85 has a half-life of 3934.4 days and it decays to the stable nuclide rubidium-85 by ejecting a beta-particle (electron). After one period of 3934.4 days, 50% of the atoms in a sample of krypton-85 will have transformed themselves into rubidium-85; after 10 half-lives (107.8 years) the sample will contain just 0.1% krypton-85 and 99.9% rubidium-85, and the radioactivity of the sample will have decreased in proportion to the amount of krypton remaining.

The emission of alpha- and beta-particles is accompanied by a release of energy, most of which manifests itself in the rapid motion of the particles ejected. This radiation is so energetic that it can strip electrons from surrounding atoms, and so 'ionise' them. The ionisation eventually dissipates itself as heat and as damage to the surrounding material. Further energy can be lost as gamma radiation, similar to X-rays but more energetic, which is also ionising.

Nuclear fission

The emission of free neutrons only occurs in a process known as nuclear fission, Here the nuclei of certain very heavy 'fissile' atoms, such as those of uranium, which have a large excess of neutrons over protons (143 neutrons and 92 protons in uranium-235), when excited by the capture of a neutron, split into two nuclear fragments, themselves highly radioactive, with the emission of a few free neutrons. In the fission process large amounts of energy are released, mainly in the form of energy of motion of the heavily ionising fission fragments. Thus a mass of fissile material exposed to neutron irradiation rapidly develops an admixture of 'fission products', and is therefore highly radioactive, at least initially.

The free neutrons emitted in the process of fission in a suitable mass of fissile material may themselves excite further atoms to undergo fission. This process is enhanced if the neutrons are first slowed down in a 'moderator' of light materials such as water or graphite. If the neutrons emitted per fission cause on average one further nucleus to undergo fission, the result is a condition known as 'criticality', a self-sustaining chain reaction. This process, properly controlled, is the basis of energy production in the nuclear power industry. In a nuclear reactor heat is generated in the fuel elements and their cladding by the ionisation caused by the fission fragments, and by the slowing down of neutrons in the moderator.

Such fission reactions are known to have occurred in nature about two billion years ago, when the natural abundance of the fissile uranium-235 (which has a half-life of 703.8 million years) was much higher than it is today.

The large fragments resulting from the fission process are in fact the nuclei of medium weight atoms. They are unstable and they absorb further neutrons, but do not undergo fission. In a nuclear power reactor they are the principal waste product of the power generation process. Eventually, due to their ability to absorb neutrons, they build up in the nuclear fuel to such an extent that the fission process is no longer efficient. At this point the fuel must be replaced. However it may still contain substantial quantities of fissile material, which may be recovered and re-used as fuel if it can be separated from the waste fission products, and this is known as reprocessing.

Problems with radioactivity

The energy released during radioactive decay causes ionisation in the matter through which the radiation passes. The concern over radioactivity arises from the resulting damage that this can cause to surrounding material, especially living tissue. The term used to describe and measure this damage is 'radiotoxicity': it depends upon the rate of decay, the type of radiation emitted (alpha-particle or beta-particle, for example), its energy, and the nature of the surrounding material. For example, some tissues are more sensitive than others. In living organisms, radiation can kill cells, can disrupt genetic material (leading to cancers) and, if the dose and dose rate are very high indeed, such as in a nuclear explosion, can kill outright. In medicine, on the other hand, these properties are used in controlled conditions to treat cancer, by preferentially killing off tumour cells.

As will be clear from the above, radionuclides can continue to emit radiation for considerable periods of time. Thus, when radionuclides are used, measures must be taken to isolate them from the environment so as to limit their potential for causing harm. This applies not only to nuclear material while in use, but also after use, and to the waste products that result. For some long-lived radionuclides the period of isolation required may be thousands or even millions of years.

The measures that have to be taken to shield against the effects of radiation depend on whether it mainly consists of alpha-particles, beta-particles, gamma radiation or neutrons, or some mixture of these. Alpha-particles can only penetrate a few centimetres of air and they can be stopped by a sheet of paper or an outer layer of skin. Because they lose all their energy in a very short distance, alpha-particles can be very damaging to soft tissue (eg in the lung or digestive system if inhaled or ingested). Beta-particles can penetrate somewhat further, although they can be stopped by a few millimetres of plastic or metal. Again, they are dangerous inside the body. Gamma radiation, which often accompanies beta-particles, will easily penetrate the human body, and can do both internal and external damage. It can only be sufficiently attenuated by thick or heavy shielding, such as lead, concrete, or some metres of water.

Neutrons can also penetrate moderate thicknesses of matter. In the course of doing so, they slow down by repeated collisions with atomic nuclei in the material through which they pass. When a neutron collides with a nucleus there will be a considerable release of energy as the nucleus recoils. This in turn causes ionisation and further damage similar to that caused by an alpha-particle. The neutron is finally stopped only when it is absorbed by an atomic nucleus, a process made more likely if it has first been slowed down. As the neutron is absorbed it may cause fission (as described above), or the release of intense gamma radiation, or some other process. In their slowing down and eventual absorption, neutrons cause damage to both living tissue and reactor components.

Water is often used as a shield for neutron radiation because it can both slow down and absorb neutrons and, if it is extensive enough, can attenuate the associated gamma radiation.

Natural background radiation

Natural background radiation includes cosmic rays, gamma radiation from rocks and soils, radon emitted into the air from rocks and soils, and radionuclides (eg potassium-40) in foods. The background radiation doses which people receive depend on where they live, their habits and their diet.

For most people in the United Kingdom natural background doses are much higher than the dose they receive from all man-made sources of radiation. The average natural background dose to an individual in this country is 2.2 millisieverts per year*. The range of background doses is from about 1 millisievert per year to about 100 millisieverts per year; the highest doses are in areas where radon levels are high, such as parts of Devon and Cornwall. The average dose to a member of the public from nuclear power is about 0.0004 millisieverts per year and the highest dose is about 0.2 millisieverts per year**.

*The unit of radiation dose is the sievert, which is defined in terms of the energy deposited per unit mass of body tissue, with weightings for the potential of the type of radiation to cause damage and for the sensitivity of tissues. A millisievert is one thousandth of a sievert.

**Data taken from National Radiological Protection Board report NRPB-R263 and MAFF/SEPA report RIFE-3.

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1 Parliamentary Office of Science and Technology (POST) Report 106, 1997: *Radioactive Waste - Where Next?* Hereafter referred to as the POST Report. Back

2 Royal Commission on Environmental Pollution Sixth Report (1976); Chairman Sir Brian Flowers (as he then was): *Nuclear Power and the Environment.* *Back*

3 ibid. Back

4 Session 1987-88, 19th Report, HL Paper 99, July 1988. Back

5 Health and Safety Executive Safety Directorate: *Intermediate Level Radioactive Waste Storage in the UK: A Review.* *Back*

Select Committee on Science and Technology Third Report

PART A: the present situation

CHAPTER 2: NUCLEAR WASTE MANAGEMENT IN THE UK

THE GENERAL SITUATION

2.1 The development of methods for the long-term management of radioactive waste is a necessity in all countries which have had nuclear programmes (see Table 1). The scale of the problem, in terms of volume, radioactive content and diversity of physical and chemical forms of the waste, depends on the size of the country's civil and defence nuclear progammes. The problems are greatest in countries which have now, or had in the past, a substantial civil programme and a substantial defence programme. These countries are the US, the former Soviet Union, France and the United Kingdom. In all these countries one important component of the problem is the waste which already exists, especially that arising from plants designed and processes carried out in the 1940s, 1950s, 1960s and early 1970s, when much less attention was paid to long-term waste management than in more recent times. A second important component is 'committed' waste, that is the waste which is bound to arise from the operation or decommissioning of plants which are operating now (and that which is expected to arise from plants which are under construction or for which there is a commitment to start construction).

2.2 This legacy of waste—existing and committed—is very much greater than any current projections of wastes from future nuclear programmes. It has to be dealt with, whether there are future nuclear programmes or not.

Table 1 Nuclear Share of Electricity Generation (as of March 1998)

Country	Percentage of electricity generated by nuclear power stations
Lithuania	81.5
France	78.2
Belgium	60.1
Ukraine	46.8
Sweden	46.2
Bulgaria	45.4
Slovak Republic	44.0
Switzerland	40.6
Slovenia	39.9
Hungary	39.9
Japan	35.2
Republic of Korea	34.1
Germany	31.8
Finland	30.4
Spain	29.3
Taiwan	29.1
United Kingdom	27.5

Armenia	25.7
United States	20.1
Czech Republic	19.3
Canada	14.2
Russian Federation	13.6
Argentina	11.4
Romania	9.7
Mexico	6.5
South Africa	6.5
Netherlands	2.8
India	2.3
Brazil	1.0
China	0.8
Kazakhstan	0.6
Pakistan	0.6

Source: From IAEA Bulletin 40/3/1998.

UNITED KINGDOM WASTE QUANTITIES AND CHARACTERISTICS

2.3 The United Kingdom maintains an 'inventory' of existing and projected future radioactive wastes. This is a database of information on waste volumes, radioactive contents and physical and chemical characteristics. It is updated regularly (approximately every three years) and is compiled by contractors for both UK Nirex Ltd and the Department of Environment, Transport and the Regions (DETR). The latest version of the inventory was issued in 1996 and refers to wastes existing and projected to arise on the basis of information available in 1994.

2.4 The United Kingdom inventory includes all civil nuclear power and defence wastes, plus wastes which arise from other sources, for example the production and use of radioactive materials in research, health care and non-nuclear industries. It does not include some materials which are held in store, for example plutonium, uranium and some unreprocessed spent fuel. These are considered to be a resource now, but may be declared to be waste in future. Some of them are fissile and their inclusion in the inventory could increase significantly the quantities of waste requiring long-term management. We discuss these materials in Chapters 4 and 7.

2.5 For the purposes of the inventory, and for general description, wastes are divided into three categories according to the concentrations of radioactive materials in them and the way they arise: high level, intermediate level and low level.

2.6 High level waste (HLW) has the greatest concentration of radioactive materials and produces substantial quantities of heat. It arises mainly as a nitric acid solution containing fission products separated from irradiated nuclear fuel during reprocessing. This solution will be 'vitrified' (ie converted into a borosilicate glass) and this process is already in operation. If unreprocessed spent fuel and plutonium were declared to be waste, they would also be classified as high level waste.

2.7 Intermediate level waste (ILW) is less radioactive. It consists primarily of metals, with smaller quantities of cement, graphite, organic materials and inorganic sludges. Most of these arise from dismantling and reprocessing of spent fuel, including treatment of effluents prior to discharge into the environment, and from general operations and maintenance of radioactive plant. ILW (for example, contaminated and activated metals) will also be produced when nuclear plants are dismantled.

2.8 Low level waste (LLW) is the least radioactive. Most of the LLW produced by the nuclear industry at present is metals and organic materials, which arise largely as lightly contaminated miscellaneous scrap. The metals are mostly in the form of redundant equipment; the organic materials are mostly discarded protective clothing, paper towels and plastic wrappings. When nuclear plants are decommissioned there will be large volumes of LLW consisting of building materials and big items of plant and equipment. Most of the radioactive waste produced outside the nuclear industry is LLW. This includes small volumes of waste arising at hospitals and research establishments (eg contaminated glassware and plastic containers). There are also rather larger volumes of waste from industries that deal with materials that are naturally radioactive (eg phospates used in the manufacture of fertilisers and detergents, zircon sands used in making abrasives and refractories, sludges and scales from the off-shore production of oil and gas). Some of this waste is formally defined as "very low level" (ie it has an activity level less than 4 Becquerels per gram) and much of it is disposed of to landfills.

2.9 The term 'conditioning' is used to mean any process by which raw waste is treated prior to disposal or long-term storage. For liquid HLW the chosen conditioning process is vitrification. For most ILW, conditioning consists of immobilisation in cement-based materials, in steel drums. Most LLW is compacted to reduce its volume, and in recent years LLW has been 'supercompacted': drums of raw waste are compacted under high pressure to form 'pucks' which are then loaded into large metal containers and concreted in place.

2.10 Figure 1 shows the volumes of existing and committed United Kingdom HLW, ILW and LLW given in the 1994 inventory (issued in 1996) and the volumes of these wastes which were forecast to arise ('uncommitted'). The total volume in stock in April 1994 was 71,000 cubic metres, of which 2.3 per cent was HLW, 86.6 per cent ILW and 11.1 per cent LLW. Although LLW is produced in the largest quantities most of it is disposed of (to Drigg[6]) soon after it arises, hence the relatively low volume in stock. The uncommitted waste arisings shown in Figure 1 are based on the following scenario:

- a national future nuclear power programme with pressurised water reactors (PWRs), but without reprocessing of spent PWR fuel,
- some future fuel manufacture for existing power stations beyond that already committed, and
- operation of THORP beyond its first ten years (ie beyond 2003).

2.11 As can be seen from the figure, the estimates of total volumes of waste predicted to arise are not very sensitive to the assumptions in this scenario. Of the total volumes, in stock and predicted arisings, 65 per cent of HLW, 88 per cent of ILW and 96 per cent of LLW are committed. (The effects on waste volumes of differing assumptions about reprocessing are discussed in Chapter 7.) On the basis of 1994 inventory information, the cumulative volume of all waste in stock and predicted to arise is 2.2 million cubic metres. Most of this is LLW (see Figure 1) and about 90 per cent of this LLW will arise when present nuclear plants are fully dismantled (see Figure 2).

2.12 Although it has the lowest volume, HLW has the highest radioactive content. The total radioactive content of all waste in stock in April 1994 was 40 million terabecquerels.[7] 90 per cent of this was in the HLW and virtually all the rest in the ILW. During about the first thousand years after production of the HLW its activity falls by a factor of about one thousand as the shorter-lived radionuclides decay (particularly caesium-137 and strontium-90, which have radioactive half-lives of about 30 years). Over about the next ten thousand years the activity of the HLW decreases by about another factor of ten, as americium-241 (half-life about 430 years) decays. After this the activity of HLW decreases more slowly until around three million years, when the quantities of radionuclides such as neptunium-237 (half-life 2.1 million years) and caesium-135 (half-life 2.3 million years) begin to fall substantially.

2.13 When it is first produced HLW emits substantial amounts of heat. As its activity decreases so does its heat output. By about fifty years after the fuel was reprocessed vitrified liquid HLW should be sufficiently cool for it to be placed in a geological repository without excessive temperature rise of the rock.[8]

2.14 As the activity and heat output of HLW decreases it becomes less hazardous. After two or three thousand years the radiotoxicity of HLW is less than that of the uranium ore from which it was derived. Uranium ore is itself hazardous and HLW does not become innocuous when its radiotoxicity falls below that of ore. Safety assessments of HLW disposal (see, for example, the European PAGIS study[9]) indicate that potential risks to humans may still be significant for hundreds of thousands of years.

2.15 For the purpose of description, ILW is often divided into two categories: short-lived and long-lived. The activity of short-lived ILW is dominated by radionuclides such as caesium-137 and strontium-90, so it falls to very low levels within a few hundred years. Ion exchange materials that are used for treatment of liquid effluents are one example of short-lived ILW. In long-lived ILW there are substantial quantities of radionuclides such as plutonium-239 (half-life 24,000 years), americium-241 and its daughter product neptunium-237 (half-life 2.1 million years), or fission and activation products such as technetium-99 (half-life 210,000 years) and chlorine-36 (half-life 300,000 years). Assessments carried out by UK Nirex Ltd show that long-lived ILW could still give rise to significant risks to humans at times longer than one hundred thousand years after its disposal (see, for example, Figure 4.6 in the POST Report1).

2.16 Although the radiotoxicity of waste constituents is the main concern, some of them are also chemically harmful to humans and other organisms. For example, most of the heavy metals are chemically toxic if sufficient quantities are ingested or inhaled. In a few cases, for example depleted uranium, chemical toxicity is of equal or greater concern than radiotoxicity[10].

WHERE THE WASTES ARE

2.17 Most HLW arises and is stored at BNFL's Sellafield site; the remainder is at UKAEA's Dounreay site. Most of the HLW is still in liquid form (see 2.6). At Sellafield the vitrification plant began operation in 1996. The canisters of vitrified HLW are kept in a purpose built store (the 'Vitrified Product Store', VPS), which has passive cooling and a back-up forced cooling system. The liquid HLW is stored in cooled tanks. In mid-1998 the VPS contained some 1,600 canisters of HLW and BNFL estimated that it would take until about 2015 to vitrify all the liquid HLW in stock. At Dounreay all the HLW is in liquid form but its volume has been reduced through a process of evaporation. Conversion of this into solid form will not start for some years.

2.18 Around 65 per cent of ILW is currently held at Sellafield (p 175). Much of this is still in raw form but a number of plants are operating, or are planned, to condition this waste. The main conditioning plants, with the dates at which they did or will start operating, and the wastes which they deal with, are:

- the Magnox Encapsulation Plant (1990, for Magnox cladding);
- the Waste Encapsulation Plant (1994, for THORP wastes and retrieved solids/sludges);
- the Waste Packaging and Encapsulation Plant (1994, for flocs and sludges);
- the Waste Treatment Plant (1996 for plutonium contaminated material) and
- the Drypac plant (2003, for swarf, sludge and miscellaneous beta/gamma waste).

At Sellafield there are several stores in use and planned to hold the conditioned waste, all of which meet modern safety standards. The stores have design lives of the order of 50 years and BNFL estimate that they could continue to be used safely for 80-100 years (QQ 81, 83-87).

2.19 The remaining ILW is held at various nuclear sites. Much of it is held at nine licensed Magnox power stations, at Dounreay and Harwell, and at Aldermaston (see pp 177-179). Again, most of this waste is in raw form and will need to be conditioned. Waste stores, with design lives of several decades or more, are in operation, under construction or planned at several sites, including Dounreay, Harwell, Winfrith and Rosyth. At the Magnox and advanced gas-cooled reactor (AGR) power stations the preferred strategy is not to build new stores for conditioned wastes. Instead the aim is to place such wastes in the 'safestores' which BNFL (at the former Magnox Electric sites) and British Energy (Nuclear Electric and Scottish Nuclear) plan to build around the reactor and other major buildings when they are decommissioned (Q 752). The safestores would also hold wastes arising from clearance of peripheral plant and buildings. The safestores would remain in place for about 130 years, to allow radioactive decay, then all wastes would be removed and disposed of, and the buildings demolished.

2.20 The only LLW which is stored is that which cannot be disposed of to Drigg (because of its volume, alpha activity or chemical composition). Most of this is at Sellafield but there are small amounts elsewhere (for example at Aldermaston).

2.21 Towards the end of our enquiry the Health and Safety Executive (HSE) published a report that reviews ILW storage in the United Kingdom[11]. The review, carried out by the Nuclear Installations Inspectorate of HSE, confirms the evidence previously given to us that a delay in providing a repository will not cause immediate safety problems for ILW storage. It also concludes that up to 20 modern ILW stores will be required for wastes currently accumulated on major nuclear licensed sites if an operating repository is not available within the next 15-20 years, and that a delay of more than 50 years will require a further costly and difficult programme of store replacements or extensive refurbishments, possibly with the repackaging of wastes.

2.22 The reactor compartments of decommissioned nuclear-powered submarines are a particular type of ILW. At present 11 defuelled submarines are being stored afloat; seven of these are at Devonport and four at Rosyth. By the year 2020 there will be about 20 defuelled submarines to store and this could rise to 50 by 2050. The storage capacity at Devonport will be full by 2016 (Q 352). The spent fuel from submarines is being stored in purpose built ponds at Sellafield, where a new pond is under construction to hold future arisings. This spent fuel has not been declared to be waste because MoD intend to have it reprocessed. RWMAC has raised doubts as to whether it will be technically feasible to reprocess submarine fuel in current plants at Sellafield and has suggested that the fuel may have to be disposed of with other HLW (p 261). For reasons of national security there are no published estimates of the volume or activity content of this fuel but the Ministry of Defence (MoD) have told us that there are at present 51 used submarine reactor fuel cores in store at Sellafield.

Uranium and Plutonium

2.23 In a report published in 1996, AEA Technology estimated that there will be 75,000 tonnes of uranium in stock by the year 2010[12]. This includes irradiated uranium separated during reprocessing, and depleted uranium produced in fuel fabrication. None of this uranium is included in the United Kingdom inventory because it is not yet considered to be waste. The corresponding quantity of separated civil plutonium is expected to be about 100 tonnes.[13] More recently, in a study for DETR, QuantiSci estimated that there could eventually be 100,000 tonnes of uranium and 150 tonnes of plutonium in store.[14]

2.24 The United Kingdom military stocks of uranium and plutonium were announced in the recent Strategic Defence Review (Cm 3999, July 1998). Various amounts of surplus fissile material were also declared. These surpluses will be placed under EURATOM safeguards and will be made subject to inspections by the International Atomic Energy Agency (IAEA) of the United Nations.

2.25 There are also other materials in store, or which may arise in the future, that contain uranium and plutonium and which may in due course be declared to be waste. These include the spent fuel from the

Sizewell B PWR, for which no reprocessing contract has yet been signed, and small amounts of fuel from other reactors which does not meet the specifications for reprocessing in current plant.[15]

FUTURE NUCLEAR POWER PROGRAMME

2.26 It can be seen from the above that the volumes of long-lived waste which exist now, and which will be generated by the present nuclear power programme if reactors continue to operate until the end of their useful lives, are substantial. Closing all existing reactors over the next few years would have little effect on these volumes, nor would the construction of a small number of new reactors. Decisions about the future civil nuclear programme will have little effect on waste volumes and, in this sense, are not strongly linked to the choice of long-term waste management option. The same is true of the future defence programme. This is not to say that there is no link between long-term waste management and future nuclear programmes: as we shall see in Chapter 5 there certainly is a link in terms of the attitudes of some sections of society. The situation for reprocessing, of United Kingdom and of foreign spent fuel, is discussed in Chapter 7.

History of Waste Management in the UK

2.27 The first major Government review of nuclear waste management in the United Kingdom was carried out in the late 1950s and its results published in 1959 in Command Paper 884, The Control of Radioactive Wastes. The next review did not take place until the 1970s, when the Royal Commission on Environmental Pollution issued its sixth report Nuclear Power and the Environment (Command Paper 6618, the "Flowers Report", published in 1976). The following summary of events since then starts with the Government's response to the Flowers Report.

1977-1981

As part of its response to the Flowers report, the Government made the Department of the Environment responsible for radioactive waste management policy (Command Paper 6820). It also increased research into the disposal of HLW and recognised the need for a national disposal facility for ILW. In 1978, it established the Radioactive Waste Management Advisory Committee (RWMAC) and in 1979 published an expert report reviewing Cmnd 884.

As part of the research on HLW disposal, the drilling of boreholes began at a site in Scotland (Altnabreac) in 1979 and later at Harwell in Oxfordshire. The aim of these and planned drilling programmes at other sites was to investigate the properties of various types of rock. The research drilling programme was discontinued in 1981, as a result of public opposition.

1982-1986

In 1982 the Government published another White Paper on radioactive waste management. This established the Nuclear Industry Radioactive Waste Executive (NIREX), which later became United Kingdom Nirex Limited (shortened to Nirex). The remit of Nirex was mainly to construct and operate new land disposal facilities for LLW and ILW, but it was also to run the annual sea dumping operation for LLW and some ILW. The Government stated that it was envisaged that HLW would be stored for about 50 years.

Sea dumping was halted in 1983 when the meeting of the international London Dumping Convention passed a non-binding resolution intended to establish a moratorium on sea dumping. Three international reviews of sea dumping of radioactive wastes were carried out, none of which precluded further dumping but all of which implied changes to dumping practices. In 1985 the London Convention meeting extended the moratorium on dumping indefinitely.

In 1983, Nirex announced its initial choice of potential new land disposal sites: a clay site at Elstow (owned by the Central Electricity Generating Board) for a near-surface facility for LLW and short-lived

ILW, and a disused anhydrite mine at Billingham (owned by ICI) for long-lived ILW. There was a great deal of local opposition at Billingham and ICI became unwilling to allow the site to be investigated. In 1984 the Government announced that Nirex would be required to investigate at least three possible sites for a new near-surface facility and at least three sites for a deep repository, excluding Billingham. In 1986 Nirex announced that they wished to investigate four sites for the near-surface facility: Killingholme, Fulbeck, Bradwell and Elstow. Special Development Orders were made for geological investigations at these sites.

In 1986 the House of Commons Environment Committee published a report on radioactive waste.[16] The Government issued its response (Cmnd 9852), which stated that only LLW would be placed in the Nirex near-surface facility, and which reaffirmed the policy of storing HLW for 50 years.

1987-1991

The Government and Nirex decided in 1987 that the investigations at the four potential sites for a near-surface facility should cease, and that both LLW and ILW should be disposed of in a deep repository. The reason given was economic. After publication of a discussion document, responses to it, and a preliminary safety assessment report, Nirex announced in 1989 its intention to investigate Sellafield and Dounreay as potential sites for the repository. Drilling began at both sites and in 1991 the decision was made to focus on Sellafield. In the White Paper This Common Inheritance (Cm 1200, published in 1990) the Government confirmed the choice of disposal in a deep repository as the long-term management option for ILW.

During this period the United Kingdom ceased its research programme on the disposal of HLW beneath (and on) the bed of the deep ocean. The Government also stated that there would be no resumption of sea dumping of ILW and LLW but the option would be kept open for disposal of large items of waste from decommissioning of nuclear plant. ***1992-1996***

In 1992 Nirex stated its intention to construct a Rock Characterisation Facility (RCF) at Sellafield. Its timetable was to submit the planning application for the RCF in 1993 and then the planning application for the repository in 1998. Nirex hoped that the repository would be operational by 2007. The RCF planning application was eventually submitted in 1994, following delays in gaining approvals to drill more boreholes. The target date for repository operation was stated to be 2010. The application was called in and the Public Inquiry into the RCF was held in 1995-96.

A Government review of radioactive waste management policy was carried out, in parallel with a commercial and economic review of nuclear power in the United Kingdom. The conclusions of this review were published in 1995 as Cm 2919. They were that the policy for radioactive waste management should be, and is, based on sustainable development. Disposal was favoured over indefinite storage and it was concluded that there was no advantage in delaying the development of a repository for ILW. The Department of the Environment was to carry out work on a research strategy for HLW.

1997-1998

In March 1997 the Secretary of State completed his consideration of the Inspector's report on the Public Inquiry into the RCF at Sellafield.

In his report the Inspector recommended that the planning application be refused. He put forward two types of reason: one type concerned straightforward planning matters, which might apply to any type of development; the other type was particular to the RCF and to the repository which might have followed it. The straightforward planning matters included the adverse visual impact of the above ground RCF buildings and spoil heaps, criticisms of road traffic and parking plans, and possible harm to the habitat of a badger clan. The main particular reason was that the proposal to build the RCF was premature. More needed to be known about the hydrogeology and geology of the site before disturbing the rock and groundwater conditions by sinking the shaft for the RCF. Also, the location of the RCF had not been shown to be the best one from the point of view of the location of the repository, and the 'potential repository zone' might be damaged by constructing the RCF.

Underlying these particular reasons were concerns about the process by which the Sellafield site had been selected and about the suitability of the site itself. The Inspector concluded that the site had not been selected in an objective and methodical manner. His Technical Assessor was of the view that the site was more geologically and hydrogeologically complex than would be expected of a choice based principally on scientific and technical grounds. He pointed out that while the preliminary safety case for a repository at the site was certainly not a patent failure, nor were its results so clearly within targets as to command any substantial degree of confidence.

The Secretary of State decided that Nirex should not be allowed to construct the RCF at Sellafield, citing in his letter to Nirex both straightforward planning matters and reasons particular to the RCF. His decision, the Public Inquiry and the events leading up to it hold lessons for the future of nuclear waste management in the United Kingdom which we will address later in this report.

The DETR project to develop a research strategy for HLW disposal began in the spring of 1997. An interim report on the project was issued in 1998. This dealt with work during the first stage of the project: a review of past and present national and international R&D and identification of a potential HLW repository development strategy, in terms of a series of key milestones and the questions that must be answered to achieve these milestones.[17] In the summer of 1997 the Government announced that it accepted the London Dumping Convention moratorium on sea dumping: the United Kingdom would not seek to use this method for disposal of any solid radioactive waste. In November 1997 the Parliamentary Office of Science and Technology (POST) published its report Radioactive Waste—Where Next?

Events during 1998, the period of our enquiry, are discussed throughout the remainder of this report.

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6 The 110 acre low level waste disposal site in West Cumbria, owned and operated by BNFL. Back

7 See glossary for explanation of terabecquerels and other units. Back

8 Review of Radioactive Waste Management Policy, Final Conclusions. Command Paper (Cm) 2919, 1995. Back

9 Commission of the European Communities, *PAGIS, Performance Assessment of Geological Isolation Systems for Radioactive Waste*, report EUR 11775, 1988. Back

10 WHO, *Guidelines for drinking water quality, 2nd Edition, Volume 1, Recommendations*, 1993. Back

11 Health and Safety Executive Nuclear Safety Directorate, *Intermediate Level Radioactive Waste Storage in the UK: A Review by HM Nuclear Installations Inspectorate*, November 1998. Back

12 R. Cummings, R P Bush et al, *An assessment of partition and transmutation against UK requirements for radioactive waste management.* Report DoE/RAS/96.007 for the UK Department of the Environment, 1996. See also QQ 1141-1211. Back

13 The Royal Society: *Management of Separated Plutonium*, February 1998. Back

14 QuantiSci, *High-Level Waste and Spent Fuel Disposal Research Strategy: Project Status at the Half-Way Point*, report DETR/RAS/98.006, May 1998. Back

15 *ibid*. Back

16 Radioactive Waste, House of Commons Environment Committee, First Report 1985-86, HC 191 Back

17 QuantiSci, *High-Level Waste and Spent Fuel Disposal Research Strategy: Project Status at the Half-Way Point*, report DETR/RAS/98.006, May 1998. Back

Select Committee on Science and Technology Third Report

CHAPTER 3: SOME OPTIONS AND THEIR ADVOCATES

THE UNITED KINGDOM'S VIEW ON WASTE OPTIONS

3.13 The United Kingdom's position on the options mirrors the international one outlined above. It is not felt to be worthwhile to conduct research on subduction zone disposal, ice sheet disposal or ejection into space. We have signed and ratified the international agreements which rule out seabed and sub-seabed disposal. A watching brief is maintained on partitioning and transmutation but it has been rejected as not feasible for existing wastes, nor for those which will arise in the future from present civil and defence nuclear programmes. The remaining options are discussed below, firstly by outlining the views of the United Kingdom advocates of variants of them.

Regulatory views

THE ENVIRONMENT AGENCY

3.14 The Agency believes that there should be an integrated programme for the management of ILW and HLW, based on geological disposal of these wastes (pp121-27). It recognises that disposal might involve a period during which wastes are maintained underground in a fully retrievable and monitored condition, to allow further studies, before a repository is backfilled and sealed, and supervision withdrawn. The instigation of an integrated programme would not necessarily mean that all ILW and HLW would be placed in the same repository.

3.15 The Agency considers that the United Kingdom should now "get on with the job" of developing a deep repository, using a stepwise approach based on sound science, openness and public confidence. The first step would be to review the science base and decide which repository concepts and geological settings can be modelled with sufficient confidence to make an initial safety case for disposal. This would lead into a site selection process consisting of identification of potential locations, surface investigations, underground investigations and eventually repository construction. In the interim wastes would be stored safely on the surface.

THE HEALTH AND SAFETY EXECUTIVE

3.16 The HSE also thinks that the best long term management option is disposal of ILW and HLW in a deep repository. It would prefer repository development to proceed without undue delay, so as to focus short-term waste management decisions and to minimise the time for which wastes are stored on nuclear licensed sites. It believes that the risks to the public and workers from surface storage will always exceed those from a well-designed and engineered repository (pp159-181).

3.17 The HSE also emphasises the need to carry on and extend current programmes of retrieving wastes from unsatisfactory facilities, and immobilisation and packaging of wastes so that they can be stored safely for the time it is likely to take to establish one or more deep repositories. A long delay in establishing a repository could necessitate additional handling and packaging of wastes which it would be preferable to avoid[21].

3.18 The HSE sees merit in establishing a new near-surface disposal facility for short-lived intermediate level wastes, so that these could be removed from nuclear sites at an earlier date than would be possible if they were to be placed in a deep repository.

Nuclear Industry Views

3.19 The nuclear industry believes that disposal in a deep repository is the best long term solution for ILW and HLW but now feels that development of a deep repository should not be rushed (BNFL pp34-40, UKAEA pp313-317, British Energy pp24-29). The industry emphasises that, once wastes have been immobilised and packaged, they can be stored in modern surface facilities for several decades. Wastes can also be kept in a monitored and retrievable condition during the operational period of the repository, which is likely to be a few decades. In the industry's view the first step would be for the Government to establish a consensus that geological disposal is the best option and to confirm that this is the United Kingdom's policy. This would be followed by an open and transparent site selection process, with adequate national and local public consultation.

3.20 Disposal of ILW and HLW in the same repository is seen as an attractive proposition. The industry pointed out that the previous United Kingdom disposal strategy might have required three repositories: one for existing ILW (to be available in the first half of the next century), one for HLW (to be available in the second half of the next century), and one for ILW which will arise from Stage 3 of reactor decommissioning in the century after that (p 28).

Radioactive Waste Management Advisory Committee

3.21 The Radioactive Waste Management Advisory Committee (RWMAC) is very strongly in favour of geological disposal, seeing it as the "only tenable option for long term management of ILW and HLW within the context of sustainable development" (pp 248-263). It has given detailed consideration to the organisational structure, procedures and research required to establish a deep repository in the United Kingdom (pp 248-262, 357-363).

3.22 RWMAC feel that the first step should be to obtain agreement that deep disposal is the correct option for the long-term management of ILW and HLW. This would be achieved through analysis, discussion and public consultation, and could take time (pp 357-363). The next step would be a Government statement of policy and implementation of an Act of Parliament which sets out the repository development process. We discuss this proposal and the organisational structure proposed by RWMAC in Chapter 6.

Views of Environmental Groups

3.23 Greenpeace is of the view that storage on the surface is the least environmentally damaging and most responsible option which is available at present (p 150-154). It believes that this would allow future decisions to be taken with the benefit of better knowledge of the environment and improved technologies. It would also allow an integrated approach to the management of all radioactive wastes. Greenpeace is firmly opposed to disposal in a deep repository, saying that it inevitably involves future contamination of the environment.

3.24 Friends of the Earth is of a similar view, seeing surface storage for the next 50-100 years as the only practicable way forward (PP 316-328). Such storage would be accompanied by a scientific programme which would pass on an increasing knowledge base to future generations and allow them to judge whether a better option exists. Any future policy, strategy and practice should cover all wastes. It believes that geological disposal is not a viable option at present.

3.25 For both Greenpeace and Friends of the Earth the cessation of waste creation, by ceasing reprocessing and closing existing nuclear power stations, is a vital part of future waste management policy.

3.26 Environmental pressure groups local to nuclear sites hold similar general views to the national groups but are also concerned about issues which are specific to their sites. Several groups have expressed dissatisfaction about the limited information available to them on the types and quantities of waste stored on site, and about deficiencies in accountability and consultation (see, for example, p17, and paragraph 5.24).

Other United Kingdom Views

3.27 The views of the other organisations and individuals who submitted evidence fall within the spectrum of those expressed by the regulators, the industry, and Greenpeace and Friends of the Earth. Trades Unions tend to favour geological disposal, provided that there is much more emphasis on monitorability and retrievability, both while a repository is operational and after it has been backfilled and sealed (see, for example, pp189-191). Those local authorities which favour geological disposal also require this emphasis. Other local authorities express views which are closer to those of Friends of the Earth and Greenpeace: they favour surface storage pending further R&D before any choice of a longer term management option is made (pp 88-93 and pp 218-224).

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21 Health and Safety Executive Nuclear Safety Directorate, *Intermediate Level Radioactive Waste Storage in the UK: A Review by HM Nuclear Installations Inspectorate*, November 1998. Back

Select Committee on Science and Technology Third Report

CHAPTER 3: SOME OPTIONS AND THEIR ADVOCATES

Options studied World-Wide

3.1 Over the approximately three decades since the start of major research and development (R&D) programmes world-wide, a variety of options have been suggested for the long-term management of long-lived radioactive wastes. These are outlined in Box 2.

3.2 Several of the options were only seriously considered for high level wastes (vitrified reprocessing HLW and spent fuel). R&D initially focused on these wastes because it was felt that they would be the most difficult to deal with, and if a long-term management option could be developed for HLW one for other long-lived wastes would follow. It was then recognised that the diversity and larger volume of ILW presented its own difficulties, and that some of the options which could be appropriate for HLW would not be so for ILW. Present international views on the options are as follows.

Box 2: Management Options for Long-Lived Radioactive Wastes

The main options

Emplacement in Geological Formations on Land

The types of geological formations considered for waste emplacement are all those in which there is likely to be low or no groundwater flow: evaporites (salt domes, bedded salt); sedimentary rocks (clays and shales); hard rocks (granite, tuff).

The emplacement geometries studied include mined caverns and tunnels, both entirely on land and under the bed of coastal seas with access from land, at depths of 300-800m; very deep boreholes (kilometres) drilled from the surface, boreholes drilled from caverns and tunnels. All repository designs include "engineered barriers", particularly backfilling and sealing materials.

The option is suitable for all long-lived wastes.

It relies on the predictable stability of geological and hydrogeological conditions over millions of years.

Indefinite Storage on or near the Surface

This is storage on or near the surface pending technological advances to render the waste harmless or to develop better disposal methods than those thought of so far.

It is applicable to all long-lived wastes.

It relies on supervision by humans and could imply repeated rebuilding of stores and repackaging of wastes.

Disposal options which are no longer being considered

Placing Wastes on the Bed of the Deep Ocean

The water depths at sites used in the 1970s and 1980s, and proposed for the future, were several kilometres, in parts of the ocean away from boundaries of tectonic plates and hundreds of kilometres from shore.

For LLW and ILW the method used was to drop canisters of waste from a ship (sea dumping).

For HLW there were suggestions to construct some kind of concrete structure on the ocean floor, as well as to use sea dumping (but with much longer lived canisters than for LLW and ILW).

Emplacement in the Sediments of the Deep Ocean

The main emplacement method studied was the use of 'penetrators': torpedo-shaped outer canisters which would embed themselves a few metres below the ocean floor, but drilling into the ocean floor was also looked at.

The characteristics of proposed sites were as for sea dumping, and for penetrators sediments had to be sufficiently plastic to close over the wastes.

The option was primarily considered for HLW.

Emplacement in the Rock beneath the Deep Ocean

This option consists of placing canisters of waste in boreholes drilled in the ocean floor. The suggested borehole depths were kilometres below the ocean floor, at sites where ocean depths are kilometres.

The option was only considered for HLW, because of its relatively small volume.

Subduction Zones

These are zones in the ocean floor where one section of the earth's crust is moving under another section. Canisters of wastes would be placed in the zone and, in principle, they would move towards the centre of the earth and would not re-emerge for hundreds of millions of years.

The option was considered mainly for HLW.

Placing Wastes in Antarctic Ice Sheets

The canisters of waste would be placed in holes drilled in the ice sheet, where they would move downwards by melting the ice, which would refreeze over them.

The option was considered for HLW only, because of its heat generation.

It relies on ice sheets being stable for millions of years.

Ejection into Space

In this option canisters of waste would be loaded into a spacecraft which would travel out of the earth's orbit.

It was considered for low volumes of waste, mainly HLW, only.

It would only be feasible with very reliable space craft, because an accident at launch or shortly after could release large amounts of radioactive material into the atmosphere, with huge health and environmental consequences.

Other options

Partitioning and Nuclear Transmutation

Partitioning means separation of long-lived radionuclides from wastes (typically by chemical means), transmutation is transforming these radionuclides into short-lived ones, or stable elements, in a reactor or using a particle accelerator.

The option is not feasible for ILW and existing HLW.

The physics of transmutation has been studied extensively, the technology less so (especially accelerators). Problem areas are partitioning, processes for making radionuclides into suitable physical and chemical forms for transmutation, and waste management processes (chemical engineering). The option would require major nuclear programmes and technological advances if it were to be used on a large scale in future.

Synroc

Synroc is a synthetic rock material which is made by mixing waste constituents with minerals; radionuclides are held within crystal lattices so would be released very slowly into any water that came into contact with the waste after disposal.

It could be used to immobilise HLW arising from reprocessing, and other HLW such as surplus plutonium.

Immobilisation of wastes in Synroc has not yet been carried out on a commercial scale. In the future it could become an alternative to vitrification for reprocessing HLW. It may be used in the US for surplus weapons grade plutonium and in the former Soviet Union for various types of HLW.

Geological Disposal

3.3 From a technical point of view, emplacement in geological formations on land always has been and still is the 'front-runner'. In some countries it is the only option which has ever been considered. Some research has been carried out into placing wastes in very deep boreholes drilled down from the earth's surface but it was concluded that this would not be practicable for substantial volumes of HLW and ILW. R&D is now focused on deep repositories, ie mined tunnels and caverns, in some instances with boreholes drilled into their floors. In most countries' R&D programmes it is envisaged that a deep repository will become operational during the latter half of the next century and may not be closed and sealed until the century after that. Meanwhile, wastes are stored on or just under the surface.

Indefinite surface Storage

3.4 This option is favoured by those who reject geological disposal as unsound or unproven, and who wish to leave future generations the freedom to develop better methods for managing wastes in the very long term. Indefinite surface storage has not been the subject of much R&D and no countries with major nuclear programmes have adopted indefinite storage as a policy.

Seabed Disposal

3.5 Emplacement on the bed of the deep ocean was considered primarily for some types of ILW but the United Kingdom also evaluated the option for vitrified HLW. In several nuclear nations it is still thought of as, technically, an excellent option for some wastes, particularly large volume items. The option is unacceptable to non-nuclear nations, especially those whose economies depend on the sea (eg Pacific island states). It is now prohibited by international agreements.

Sub-seabed Disposal

3.6 This option was only considered for HLW because of the logistics and costs of emplacing the larger volume ILW in the sediments or rocks beneath 3-4 km of water. The international R&D programme on sub-seabed disposal, set up by the Nuclear Energy Agency of OECD[18], concluded that it would be technically feasible, given sufficient R&D, and that its radiological impact on human health and the environment could be kept low. The option was always politically and socially unacceptable to many nations, in the same way as seabed disposal, and it is now prohibited by international agreements.

Subduction Zones

3.7 Placing wastes in subduction zones was also only considered for HLW because of logistics and costs. R&D on the option was confined to paper studies, from which it was concluded that, for the foreseeable future, there would not be enough confidence in predictions about the fate of the wastes. The option also suffers from the same political and social objections as seabed and sub-seabed disposal.

Ice Sheets

3.8 This option relies on heat from wastes to melt the ice and achieve the required disposal depths. It was thus only considered for HLW. From preliminary paper studies it was concluded that there would never be enough confidence in predictions of the fate of wastes, and that there was the potential for releases of radioactive materials into the ocean. Subsequently, concern about the preservation of the Antarctic environment became another strong reason for rejecting this option. It is now ruled out by international treaties.

Ejection into Space

3.9 Initially this option was suggested for HLW but it was also thought about for low volume residual wastes from partitioning and transmutation. It was never included in major R&D programmes because the radiological consequences of an accident in which waste became dispersed in the atmosphere would be so large. The Challenger disaster reinforced opposition to the option.

Partitioning and Nuclear Transmutation

3.10 Partitioning and transmutation (P&T) was first suggested over thirty years ago as a means of reducing the long term toxicity of radioactive wastes. This would be achieved by transmuting long-lived radionuclides into shorter-lived radionuclides, or stable elements, by irradiation with neutrons. The transmutation could take place in a nuclear reactor or in the target of a particle accelerator. Partition is the process of physically or chemically separating the long-lived radionuclides and would be needed prior to transmutation. Initially P&T was considered for HLW and particular constituents of spent fuel (eg iodine-129). Latterly, transmutation has been proposed to deal with surplus military plutonium in the former Soviet Union and the US.

3.11 R&D on P&T began in the 1970s and continues in several countries, particularly France and Japan. Despite the effort devoted to it, P&T is still at the experimental stage and use of it on a large scale would require significant technological developments. For example, in France it is anticipated that the development and introduction of the technology would take between twenty and forty years. This technology is for use of P&T as an intrinsic part of nuclear fuel cycles: there is now general agreement that it is not feasible to use P&T to deal with existing HLW or spent fuel. It is also impractical to use P&T for ILW and LLW, in which the radionuclides of interest are dispersed throughout large volumes of material.[19] P&T is thus not a solution for the waste legacy, nor for wastes that will arise in future from present nuclear programmes.

Synroc

3.12 We heard evidence from the Earl of Shannon and other representatives of Synroc International about the potential of this synthetic rock material to immobilise HLW and other wastes (QQ 1083-1140). The Synroc process was invented in the late 1970s by Professor Ted Ringwood of the Australian National University and consists of mixing waste constituents with minerals to produce a solid in which the radionuclides are held within the lattices of crystals. The process has not been demonstrated on a commercial scale but may be applied soon in the US to immobilise weapons grade plutonium prior to its disposal[20]. BNFL is examining the technology and we support the continuation of this work.

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18 OECD: Organisation for Economic Co-operation and Development Back

19 R. Cummings, R P Bush et al, *An assessment of partition and transmutation against UK requirements for radioactive waste management.* Report DoE/RAS/96.007 for the UK Department of the Environment, 1996. See also QQ 1141-1211. Back

20 Sunday Times, 4 October 1998. Back

Select Committee on Science and Technology [Third Report]

CHAPTER 3: SOME OPTIONS AND THEIR ADVOCATES

Recent International Experience

3.28 We outline below the situation in those countries we visited during the course of our enquiry, namely the US, Canada, Sweden and France. We are aware that there are substantial nuclear waste management problems in other countries, particularly in Eastern Europe, but we did not examine these.

United states

3.29 The scale of the radioactive waste management problem in the US is bigger than that in the United Kingdom in terms of volume of long-lived wastes, but similar in terms of diversity. HLW in the US is primarily unreprocessed spent fuel, but there is also some HLW from reprocessing and weapons grade plutonium which has been declared to be waste. Broadly speaking, US transuranic (TRU) waste is what we would call long-lived ILW. It has mostly arisen from defence-related processes.

3.30 After about twenty years' work, the US geological repository for TRU waste is about to become operational. This is WIPP (the Waste Isolation Pilot Plant), which is located in bedded salt at Carlsbad in New Mexico, and for which the long-term safety case has been made to the satisfaction of the regulators. In contrast, work on the US repository for HLW, at Yucca Mountain, (Nevada) is at an early stage. Here underground research is in progress, but levels of local and national opposition to constructing the repository at this site are high.

Canada

3.31 No reprocessing has been carried out in Canada. Its HLW consists of unreprocessed fuel from CANDU[22] reactors and there are only small amounts of long-lived ILW. The main recent development in Canada was the publication, in early 1998, of the report by the Nuclear Fuel Waste Management and Disposal Concept Environmental Assessment Panel. This concluded that, from a technical perspective, the safety of the Canadian nuclear industry's deep repository concept had been demonstrated adequately for a conceptual stage of development, but that this was not the case from a social perspective. The panel reached the conclusion that geological disposal has not been shown to have broad public support and recommended that selection of a repository site should not begin. During our visit to Ottawa, the Chairman of the panel made the point to us that failure to demonstrate acceptability is not synonymous with a clear indication of unacceptability. The problem with the Canadian approach hitherto was that it had not included a comparison of their geological disposal concept with any alternatives, and that it was not meaningful to consult the public about the acceptability of one option without the context of others. Hence the panel recommended, inter alia, that there should be development and comparison of various long-term management options, within an ethical and social assessment framework.

3.32 The Canadian government responded to the panel's report in December 1998. It stated that it agreed with most of the panel's recommendations and with the intent of the rest. The government said that it expects producers and owners of Canadian nuclear fuel waste to establish a waste management organisation, incorporated as a separate legal entity and financed by a special fund. The organisation is to develop and compare waste management options, and to implement the preferred approach for long-term management, including disposal of nuclear fuel waste. The organisation is to report to government on its preferred approach and its justification, including a comprehensive public participation plan, an ethical and social assessment framework, and a comparison of the risks, costs and benefits of options. The government will determine whether it accepts the preferred approach.

Sweden

3.33 The nuclear waste problem in Sweden is much smaller than that in the United Kingdom: essentially the only long-lived waste they have to deal with is unreprocessed spent fuel from light water reactors. Sweden is proceeding in a measured and open fashion with geological disposal of spent fuel. The aim is to have a demonstration emplacement of a small quantity of fuel in a repository by about 2010, for the repository to be fully operational by about 2020, and for it to close around 2050/60. Until closure the waste will be monitored and retrievable. A process for selecting a repository site is in progress, using a volunteering approach, ie an approach based on seeking a community which might volunteer to 'host' a repository. So far this has not been successful but the last attempt failed by only a small margin in a local referendum and there is confidence that a site will eventually be selected.

3.34 Spent fuel is at present stored in a central facility below the ground, CLAB. A repository at Forsmark for LLW and short-lived ILW began operation in 1988. It is at a depth of about 60 metres, in crystalline rock beneath the Baltic Sea.

3.35 It is the present policy of the Swedish government that nuclear power will be phased out some time in the next century. It is not entirely clear when this might be or what alternative energy sources could replace nuclear power. Meanwhile, existing nuclear power stations are being refurbished.

France

3.36 France has a substantial civil nuclear programme, reprocesses its own and other countries' spent nuclear fuel and has a defence nuclear programme. The waste management problems in France are of a similar scale to those in the United Kingdom but are less technically complex, because there has been one predominant type of nuclear reactor: the pressurised water reactor (PWR). This means that there are fewer types of ILW and rather less long-lived ILW than in the United Kingdom.

3.37 Since about 1969 France has disposed of LLW and short-lived ILW in near-surface engineered facilities. The first of these, Centre de la Manche, became full and closed in 1994. The site is being sealed ready for a long period of institutional control (300 years), during which time the radioactive content of the short-lived ILW will decrease to that of LLW. The second facility, Centre de l'Aube, began accepting waste in 1992 and has the capacity for about 30 years' waste arisings.

3.38 France has been studying deep geological disposal of HLW and long-lived ILW since the 1970s. Investigations began at four sites in 1987 but ceased about two years later as a result of public opposition. A government review of the management strategy for HLW and long-lived ILW was then carried out (which included public hearings) and this led, in 1991, to the passing of a law which set out the framework for R&D on management and disposal of these wastes over a 15 year period. The framework requires that at least two potential repository sites be established with underground laboratories and that the sites to be chosen via proposals from local communities. So far, three sites have been selected by this process.

3.39 The framework includes taking a decision on the chosen repository site by the year 2006. We were told during our visit to France in October 1998 that it was becoming doubtful that this deadline would be met, primarily because of opposition at the national political level. Green parties in France are opposed to nuclear power and to geological disposal (instead they favour surface or near-surface storage). Nevertheless, in early December 1998 the French government announced that an underground laboratory is to be constructed at one of the sites being investigated: the Est clay site at Bure in Meuse département. A centre for research into reversible emplacement of waste underground is to be constructed near another clay site at Gard (near Marcoule). The third, granite, site (Vienne) has been found to be unsuitable and a search will start in 1999 for a possible site for an underground laboratory in granite. At the same time the government announced reforms of French nuclear safety supervision. These include the creation of an independent nuclear safety authority that will present an annual report to parliament and the chairman of which can be called before parliament to answer questions.

Views of International Agencies

3.40 We heard evidence from representatives of the United Nations' International Atomic Energy Agency (IAEA, QQ 1605-1652) and the European Commission (QQ 1338-1391), and in Paris we saw staff of the OECD's Nuclear Energy Agency (NEA). All three organisations act on the basis of a consensus among their member states and their work on long-lived radioactive wastes is focused on geological disposal.

3.41 The IAEA is establishing safety standards for geological disposal; these are mainly qualitative at present and there is resistance from some member states to more quantitative standards. It also runs co-ordinated research programmes and arranges peer reviews of its member states' repository research and their safety assessments (Q 1646). An important part of its work is to provide assistance to less developed countries, particularly to help them establish the infrastructure and regulatory systems required to manage radioactive wastes to the same standards as in developed countries (Q 1639, Q 1643).

3.42 In the past the IAEA put considerable effort into the promotion of international (regional) repositories, for example in Africa. This effort was unsuccessful and there are conflicts at the international level between those who wish to establish regional repositories and those who want to ensure that wastes are not transported across national boundaries (Q 1627-1629).

3.43 The European Commission aims to develop and implement a strategy for radioactive waste management at the European Union level. It also has a considerable programme for providing advice and technical assistance to other countries, particularly those in central and eastern Europe who wish to join the European Union and the countries of the former Soviet Union (Q 1338, Q 1355). The Commission funds and co-ordinates research in Member States and provides a forum for discussions amongst regulators, with a view to the harmonisation of standards and regulations (Q 1343).

3.44 The Commission wishes to encourage the development of repositories that can accept wastes from more than one country but has encountered opposition from some Member States: it now tends to focus on the objective of the European Union being self-sufficient in waste disposal (Q 1357-1360). Like the IAEA it sees difficulties in establishing detailed standards for radioactive waste management (Q 1377). It is working on a "communication" on the need for geological disposal, in an attempt to encourage member states to move forward (Q 1383). The Commission is also involved to some extent in producing information for the public about radioactive wastes and their management (Q 1385).

3.45 NEA acts mainly in a co-ordinating and peer review role for its member states. It is strongly supportive of the concept of geological disposal, but has noted that there is a reluctance to proceed to disposal with large and irreversible steps. Initial phases can include extended storage and retrievable emplacement. Such phased programmes are motivated by a need to build public confidence in the geological disposal option and in the competence of disposal organisations and regulators.

3.46 From IAEA, the European Commission and NEA we gained the impression that progress at the international level, particularly on regional repositories, is dependent on progress in individual countries that are developing their own repositories.

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22 CANDU: Canadian Deuterium Uranium reactors. Back

Select Committee on Science and Technology Third Report

PART B: DISPOSAL AND STORAGE

CHAPTER 4: TECHNICAL ANALYSIS

4.1 In this chapter we examine the present United Kingdom policy for the management of nuclear waste, looking first at intermediate and high level waste and then the issues raised by low and very low level waste. We continue with an examination of the technical aspects of the courses of action which focus on geological disposal, then move on to indefinite storage. The organisational changes that are required to implement strategies effectively are discussed in Chapter 6, after consideration of public acceptance in Chapter 5.

MANAGEMENT STRATEGY FOR ALL INTERMEDIATE LEVEL AND HIGH LEVEL WASTES

4.2 Since the early 1980s, when the decision was taken to focus R&D on disposal of ILW rather than on disposal of HLW, the United Kingdom approach to the long-term management of long-lived wastes has become increasingly fragmented. There are now several types of long-lived wastes, and materials which may be declared to be wastes, for which no long-term management option has been proposed or examined in detail. These wastes and materials include submarine reactor compartments, spent submarine fuel, spent PWR fuel, depleted uranium, surplus plutonium and reactor Stage 3 decommissioning wastes (see Chapter 2). There is a consensus amongst regulators, the nuclear industry, and groups such as Greenpeace and Friends of the Earth that this situation is not satisfactory. The general feeling is that a more integrated approach is needed (see Chapter 3) in which long-term management methods are identified and implemented for all wastes, and decisions are taken on the fate of all other materials held in store.

4.3 An integrated approach is required particularly if geological disposal is to be adopted, and this goes beyond the need to consider 'co-disposal' of ILW and vitrified HLW. The DETR project on a research strategy for HLW and spent fuel disposal is highlighting the necessity to be clear about the wastes which a repository is to be capable of holding before planning a research and development programme[23]. It follows that any new search for potential deep repository sites should be carried out bearing in mind all long-lived wastes and materials that may be declared wastes. Ideally decisions would be made in the near future as to which materials are wastes. This is particularly the case for plutonium because, for reasons connected with criticality risks, its inclusion as a waste would have a significant effect on repository size and design (see also Chapter 7).

4.4 At present it is not clear whether it would be feasible to find a site for one repository which is physically large enough and has sufficient radiological capacity to take everything. QuantiSci have estimated that a vitrified HLW and spent fuel repository could be several times larger than the proposed Nirex ILW repository[24]. This implies that a single repository for all long-lived wastes would require a considerable volume of rock with the appropriate physical and chemical characteristics. It may be that it is only after site investigations that a decision can be taken on whether there should be one deep repository or two. This would have to be declared at the start of a site selection process (see Chapter 6). Similar problems of siting could occur if a strategy of indefinite storage were adopted.

4.5 The United Kingdom inventory of radioactive wastes (see Chapter 1) would be much more valuable as a tool for development of an integrated strategy if it included all the materials which may be declared to be wastes. The current convention of excluding materials such as plutonium, depleted uranium, and spent fuel for which there are no definite plans for reprocessing, can lead to gaps and inconsistencies in national planning for waste storage and disposal.

Reactor decommissioning wastes

4.6 While BNFL Sellafield has adopted a policy of using purpose built stores, British Energy and the Magnox stations (now owned by BNFL) intend to store some wastes in the 'safestore' structures which they plan to erect to enclose their nuclear plants after the initial stages of decommissioning (Q 752). The intention is that these structures will be in place for over a century, while radioactivity levels in the plants decay. They will then be opened, wastes will be retrieved and plants dismantled, and the sites will be completely cleared. This safestore strategy implies that a substantial volume of wastes will not be in a form which is suitable for emplacement in a deep repository until the beginning of the century after next. It would be necessary to examine the safestore, and other decommissioning strategies, because of their influence on any new repository development programme, and to adjust the strategies, or the programme, so that there are no inconsistencies in timing.

Nuclear powered submarines and their spent fuel

4.7 RWMAC and NuSAC have called for all civil and defence waste to be dealt with in a single coherent manner (p 261, QQ 737-738). Much of MoD's waste is subject to civilian regulation and it is relatively straightforward to bring it into an integrated national strategy. This is not true of decommissioned nuclear powered submarines, which are at present stored afloat, nor of the spent submarine fuel which is currently in store at Sellafield and which may be declared to be waste (see Chapter 2). MoD appears to have no firm plans for the long-term management of the submarines and their spent fuel: their present policy is to continue current storage arrangements for decades and review the situation at intervals. This carries the risk that at some unknown date in the future MoD will request space in a store or repository for civilian wastes, when such space cannot be made available. It is essential that this is avoided. The long-term management of submarines and their spent fuel should be considered fully in the development of an integrated national strategy and MoD policy brought into line with this strategy.

Short-lived ILW

4.8 There is also the question of how short-lived intermediate level wastes should be managed. When Nirex was set up it was intended that these wastes would be disposed of in a near-surface engineered facility, as is done in France, Spain and Japan, for example (see Chapter 1). Some witnesses said that the later decision that short-lived wastes should be placed in the proposed deep repository seems to have been taken hurriedly, and for pragmatic rather than strategic reasons (eg Q1017). There is now some support, particularly from HSE and from smaller users of radioactive materials, for a return to the idea of a near-surface disposal facility for short-lived ILW (p 160, p 235, QQ 703-706).

4.9 Nycomed Amersham (a supplier of radiochemicals for use in medicine, biotechnology and other industries) said that there was a good case for building a surface decay store for short-lived ILW from 'small users'. This would provide a safe, cost effective and more easily manageable alternative to deep disposal. The company said that it would then only have to send about one to three percent of its radioactive waste for long-term storage or deep disposal; almost all of the other wastes would decay to background levels in under 50 years (p 234). Nycomed Amersham suggested using an existing waste disposal site (i.e. Drigg or Dounreay) for the short-lived ILW store. Another witness suggested that unused civil defence bunkers, which already had radiation shielding, could be used (p 279).

4.10 BNFL point out that the volumes of their short-lived wastes are small compared to those of long-lived wastes, so it is not worthwhile to develop a separate disposal facility for them (QQ 124-126). One problem in advocating different treatment for short-lived ILW would be the need to segregate it from other wastes. This would also require the waste to be given a new classification based on the half-life.

4.11 Nycomed Amersham (p 234), the Joint Trade Unions (p 190), Sir John Knill (p 198), NuSAC (p

156), HSE (p 160, Q 703) and British Energy (p 28) all called for waste to be reclassified in terms of half life, activity level and other radiological characteristics. This is something that RWMAC also said was worth developing after a preliminary study which it described in its 17th Annual Report (July 1997). British Energy agreed and told us that it would prefer a classification of waste on the basis of radiotoxicity, which would move the emphasis to a biological approach (QQ 768-770). However, BNFL was unsure of what benefits this would bring: if the aim was to allow short-lived ILW to be disposed of at Drigg then all this required was a new authorisation for the site (Q 125). The Joint Trade Unions noted that if Drigg were to take short-lived ILW then a new near surface repository would be required sooner than currently anticipated because Drigg would fill up faster (p 190).

4.12 We consider that it would be impractical for large waste producers to separate out old wastes (in particular those which have already been conditioned) and for them segregation of short-lived ILW from long-lived ILW would have few advantages. However, for small users who only (or mainly) produce short-lived ILW segregation could be simple and might also bring commercial advantages. These small users should commission a study of the options for management of their short-lived ILW, including the provision of a national decay store (from which wastes would be transferred to a LLW disposal facility when their activity had decayed sufficiently), and the direct disposal of their short-lived ILW to Drigg. They would then be in a position to make a formal proposal to regulators and Government.

LOW AND VERY LOW LEVEL WASTE

LOW LEVEL WASTE

4.13 There is currently only one major designated facility for disposal of LLW in the United Kingdom. This is the Drigg facility which is close to Sellafield and is owned and operated by BNFL. In the past there has been some disposal of LLW to a facility at Dounreay but the future of this is under review[25].

4.14 We were told when we visited Drigg that its "radiological capacity" will be exhausted by about 2050, i.e. that by then it will not be possible to emplace anymore LLW at the site because of its potential long term radiological impact, although there could well be the physical space to do so. HSE also said that Drigg could close in the period 2030-2050 (p 160). As can be seen from Chapter 2, large volumes of LLW will arise after 2060, when present nuclear power stations are fully dismantled. There could be about 2 million cubic metres of LLW requiring disposal at this time (see Figure 2). It is therefore clear that one or more new disposal facilities for LLW will be needed when Drigg closes.

4.15 At present much of Drigg's capacity is reserved for LLW from Sellafield. There could be advantages in establishing a new disposal facility well before Drigg closes, to take waste from sites other than Sellafield. British Energy have waste which cannot be disposed of at Drigg under the present authorisation and operating regime, but which could be disposed of safely as LLW (p 25). MoD are concerned about wastes which could arise from remediation of contaminated land. They are unable to estimate the volumes of such waste (P 343) and some of it has radioactive and chemical (non-radioactive) contamination (Q 321). The problems associated with waste disposal can strongly influence priorities for land remediation and sale (Q 321).

4.16 As HSE point out (p 160), a new disposal facility for LLW might well encounter some of the public acceptance difficulties associated with a deep repository. These difficulties might be reduced if the site selection process for a LLW facility was subsequent to that for a deep repository. This approach could still lead to the facility being operational before Drigg closes, and help to avoid the consignment of LLW to a deep repository by default, which would be inefficient and costly.

Very Low Level Waste

4.17 In principle the less radioactive LLW, including that which is technically defined as very low level waste (VLLW)[26], can be disposed of to landfills. Nuclear industry use of this disposal route has declined in recent years, although it is still employed to some extent, and it is employed by many organisations outside the nuclear industry (e.g. hospitals, the mineral sands industry). In the 1995 review of radioactive waste management the Government decided not to encourage greater use of this disposal route because of opposition from local authorities, environmental groups and members of the public[27]. We heard from local authorities that there continues to be strong opposition to disposal of nuclear industry LLW to landfills (see, for example, the National Steering Committee of Nuclear Free Local Authorities, p 222, Manchester City Council, p 201, West Dunbartonshire Council, PP 402-403). MoD said that the reluctance of local authorities to sanction landfill disposals of VLLW left them without a nationally approved disposal route for this waste, and that they are considering ways to solve this problem (Q 320).

4.18 We did not receive any evidence on alternatives to landfill disposal, nor have we considered this issue in detail. However, we recommend that the Government does so, in order to produce a national policy that is accepted by local authorities, landfill operators, the nuclear industry, and all those who currently use landfill disposal, rather than leaving matters almost entirely to local negotiations.

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23 QuantiSci, *High-Level Waste and Spent Fuel Disposal Research Strategy: Project Status at the Half-Way Point*, report DETR/RAS/98.006, May 1998. Back

24 RWMAC, *The Radioactive Waste Management Committee's Advice on The Interim Report of the High Level Waste and Spent Fuel Disposal Research Project*, November 1998. Back

25 HSE and SEPA, *Safety Audit of Dounreay*, 1998. Back

26 Very low level waste has an activity level below 4 Bq/g. Back

27 *Review of Radioactive Waste Management Policy, Final Conclusions*, Command Paper (Cm) 2919, 1995. Back

Select Committee on Science and Technology Third Report

CHAPTER 4: TECHNICAL ANALYSIS

GEOLOGICAL DISPOSAL OF HLW AND ILW

4.19 The evidence given to us shows that there is a strong international scientific and technical consensus that there is enough confidence in geological disposal of HLW and ILW to make it worthwhile to work towards it (see Chapter 3 and, for example, p 136, QQ 957-959). Only a small minority in the geological community, and in other disciplines, feel that there is so little confidence in geological disposal that it should be abandoned, or that it should cease to be the focus of most R&D (see, for example, Friends of the Earth, pp 322-328).

4.20 Various courses of action can be defined which involve proceeding with geological disposal, using surface storage until one or more deep repositories are available. At one end of the scale is the strategy followed over the last decade in the United Kingdom, in which the surface storage period was planned to be as short as possible, and it was envisaged that the repository would be finally sealed when all the wastes had been emplaced[28]. In the middle of the spectrum of courses of action is a strategy with a surface storage period prior to emplacement in a repository, and a long time in which a repository is kept open with wastes in a retrievable form (see, for example, p122, QQ1706-1714, QQ545-547). At the far end of the spectrum of courses of action is indefinite storage of long-lived wastes on the surface, combined with an R&D programme on longer-term management methods including, perhaps, geological disposal (see, for example, Friends of the Earth, P318).

Status of knowledge

4.21 The main scientific determinant of the way to proceed with geological disposal is the ability to predict the performance of a deep repository over the hundreds of thousands of years it will take for the radioactive constituents of the wastes to decay to very low levels. By "performance" we mean the capability of all the parts of a repository to prevent releases of radionuclides and/or to slow down their rates of movement into the surface environment. Assessments of repository performance are necessarily probabilistic because it will never be possible to predict exactly what will happen over such long times. Rather the aim is to identify possibilities and to quantify, or at least describe, uncertainties. Performance assessment is a mixture of quantitative analyses, using mathematical models (for example, of radionuclide migration with groundwater), semi-quantitative analyses ("scoping calculations") and qualitative reasoning[29]. Similarly, the criteria by which the adequacy of predicted repository performance will be judged are both quantitative and qualitative[30].

4.22 . The research carried out to date world-wide has increased considerably the ability to assess repository performance over very long times.[31] Initial "guesstimates" about the rates at which waste packages will corrode and the rates at which radionuclides will be leached out of wastes into groundwater have been replaced by firmer estimates, based on better understanding of the physical and chemical processes involved. Very simple generic models of rates and patterns of groundwater movement and radionuclide migration have been superseded by models founded on site specific hydrogeological and geochemical conditions. Some processes which were omitted entirely from early performance assessments can now be included (for example, the generation of gases such as hydrogen when metallic wastes and waste canisters corrode under anaerobic conditions in a repository).

4.23 . Nevertheless, there are still significant gaps in knowledge. One of the most important for a deep repository in the United Kingdom concerns the effects of future changes in climate on rates and patterns of groundwater flow. It is possible, using probabilistic techniques and palaeoclimatic data, to generate a series of possibilities for how climate may change in the future and to provide probability estimates for these sequences of climatic conditions. Thus probabilistic predictions can be made of rates and magnitudes of changes in sea level, and of the timing and extent of future glaciations. Means to predict the effects of climate changes, particularly glaciations, on rates and patterns of groundwater flow are, however, at present incomplete. Techniques such as palaeohydrogeology, in which attempts are made to reconstruct past groundwater conditions as an indicator of future ones, are in their infancy.[32]

4.24 Similarly, advances in scientific knowledge are needed before the effects of seismic events on groundwater flows can be predicted with any confidence. For fractured rocks, in particular, there are problems in characterising the rock in enough detail to be able to model groundwater flow through it, without disturbing it so much that repository performance is affected (Q 925). While rates of generation of bulk gases can be quantified if groundwater conditions are known, much less has been done on the effects of gases on water flow patterns and on the transition period when a sealed repository is resaturating. Quantitative prediction of the rate of evolution of chemical conditions within and around a repository is not yet possible[33]. For example, for a repository with a cementitious backfill, it is not known how long it will take to establish the conditions in which the solubilities of most radionuclides will be very low, nor how the movement of the minerals in the backfill will affect radionuclide migration. A further major type of uncertainty is the extrapolation of the results of short term laboratory experiments to thousands of years, and longer. This applies to canister corrosion, waste leaching and the sorption of radionuclides on geological media. These gaps in knowledge are not a reason for postponing action: they are a reason for increased effort.

Repository Timing

4.25 In the technical evidence presented to us the predominant scientific view is that enough is known to begin a deep repository site selection process in the United Kingdom (for example, p29, p136, p224, p245). It will be necessary to begin by establishing clear site selection criteria (geological and other), then to perform desk studies to identify sites for preliminary field investigations. The next steps are to decide which sites merit more detailed investigations and to carry these out (pp 254-255). Based on scientific and technical considerations, we estimate that these steps are likely to take at least a decade. The need to build public confidence (see Chapter 5) could prolong this.

4.26 To plan interim surface storage arrangements and repository related research it is essential to take a view on how rapidly to proceed with repository construction and operation once the repository site (or sites, see para 4.4) has been selected. Concerns about the ability to monitor and retrieve the wastes are a major consideration here. We believe that it is essential not to proceed from one stage to the next until there is a sound technical basis for doing so, and ideally the programme would contain no, or very few, points of no return.

4.27 A repository can be built and operated so that there is monitoring during the operational period (eg of the integrity of waste packages) and so that it is relatively easy to retrieve wastes if necessary (eg Q1417). The repository operational period can, in effect, be made one of underground storage. It will also be possible to retrieve wastes after a repository is backfilled and sealed, although retrieval would then be more difficult and might pose significant risks to the workers involved (eg Q1418). In developing a repository design it is necessary to decide how much ability to monitor and retrieve should be built in, for both the operational period and after closure, without compromising long term safety (Q 1011)[34] [35].

4.28 In our opinion, the best course of action would be to begin repository construction without undue delay after site selection, and to place wastes in the repository in such a way that they can be monitored and retrieved, only backfilling and sealing the repository when sufficient knowledge has been judged to be gained. We do not believe that the length of the period for which the repository is to remain open needs to be, or should be, prescribed precisely now, but it is necessary to have some idea of how long it might be. The minimum would be several decades, to allow sufficient time for research and observation of waste packages underground. To proceed more rapidly to repository closure would not give the flexibility to adjust development programmes in the light of research findings, and would be unlikely to satisfy desires for monitorability and retrievability.

4.29 We believe that it is important that repository operation starts within the next fifty years, before a major programme of store replacements or refurbishments, perhaps with repackaging of intermediate level wastes, is required[36]. We are therefore not in favour of delaying the start of the United Kingdom site selection process until further research has been carried out. Expert opinion is that such research might take a decade or two (Q 938). Adding this to the one or two decades for site investigation and selection, and a few years for construction and commissioning, means that a repository would only just be ready to receive wastes fifty years from now. There would be no leeway in such a programme, and a danger that the latter stages would be carried out with undue haste. We believe that research is best carried out in parallel with site selection, and subsequently when wastes are emplaced in a monitored and retrievable way.

4.30 The above course of action might be described as a combination of surface storage, underground storage and geological disposal, or a phased approach to geological disposal. It is the course we favour.

INDEFINITE STORAGE

4.31 We use the term indefinite storage to mean storage on or just below the ground surface while R&D is carried out on longer-term options. Such a strategy implies that something else will be done with wastes eventually, but that it is not known now what this will be or when it will occur. This differs from permanent storage, which carries no implication of different actions in the long term, and which is not a tenable strategy (see, for example, Cm 2919 and evidence from Friends of the Earth, p318).

4.32 Surface storage of conditioned, packaged wastes in modern facilities for several decades is feasible and safe (p 156, p 160). Beyond periods of this length it will be necessary to refurbish stores extensively and perhaps replace them. Repackaging of wastes may also become necessary [37].

4.33 Storage for several centuries raises much greater problems. The major one is the likelihood of societal breakdown. World-wide, there are many examples of civilisations which have appeared and disappeared within a century. If this occurred to our civilisation, stores, wastes and packages would degrade, and R&D on longer-term management options would cease. Eventually there would be rapid and substantial leakage of radionuclides into soils and groundwater, and perhaps into the atmosphere. Even a lesser change in society would be serious if it led to stores falling into disrepair, and wastes and packages degrading to such a degree that it would be risky to retrieve packages and very difficult to convert wastes to a stable form again. The maintenance of facilities does not always receive the economic priority that it deserves.

4.34 Over several centuries there could be climatic changes (particularly sea level rises) which would make it necessary to move wastes to new stores in other locations. This would entail risks, particularly to workers. Another concern is that over centuries the foundations and reinforcement in stores could weaken, making them more vulnerable to earthquake damage. Again this would necessitate building new stores and moving wastes to them.

4.35 A further problem with indefinite storage is the R&D programme to accompany it. We have not been able to find in the evidence presented to us, or in the literature, any definite suggestions as to what R&D might be carried out to look for new long-term management options. Many methods have been thought about, and some have been the subject of much research, but has been found to be more promising than geological disposal for the ILW and HLW which exists now and which will arise from the current civil and defence nuclear programmes (see Chapter 2). In view of these difficulties we do not favour indefinite storage as a policy.

RESEARCH REQUIREMENTS

4.36 With a phased approach to geological disposal of the type outlined above, research would be carried out in three steps:

· before the deep repository site selection programme starts and while it is in progress;

· after the site (or sites) has been selected, during repository construction and waste emplacement;

· while wastes are underground in monitored and retrievable form, before the repository is sealed.

4.37 In each phase there would be a need for multi-disciplinary research, covering, in particular, geology, hydrogeology, geochemistry, and the materials science relevant to the behaviour of wastes and their packages under disposal conditions. Processes in the surface environment (the "biosphere") also merit attention, primarily from the point of view of how they affect conditions at depth (for example, how changes in sea level and rainfall could affect groundwater flow).

4.38 The first phase of research would be largely generic and would be partly aimed at assisting site selection and repository design. It will be important to address the wastes which were not included in the Nirex deep repository programme (vitrified high level waste, spent fuel, depleted uranium, surplus plutonium etc). For some of these wastes much can be gained from research carried out in other countries. Development of means to build into a repository the ability to monitor and retrieve the wastes should be included, because there has been little work on this in the United Kingdom to date. Although the ability to monitor and retrieve wastes while the repository is open is the first priority, it would be valuable to consider what could be done for the post-closure period.

4.39 The second phase of research would be mainly site specific. It would include experimental work at the repository site (or sites), in addition to site characterisation activities. The third phase of research would be a continuation of the second, but with the addition of observations of waste packages and groundwater conditions in the repository.

4.40 As well as disposal related research, it would be necessary to carry out some work on surface storage. Amongst the aims of this R&D would be to provide better estimates of the length of time for which such storage could be maintained without carrying out major operations, and to develop the technology for repackaging wastes. This would be needed if there were unforeseen delays in the repository development programme.

4.41 It has been suggested that future United Kingdom R&D on geological disposal should include establishing an underground laboratory at a site which will never be used for a repository. While such a laboratory would have been valuable in the past, there would be little merit in having one in the future if a search for deep repository sites were to be started soon. United Kingdom researchers have made good use of underground laboratories in other countries for generic studies. They could continue to do so until our site selection process was complete and then move on to site specific research.

4.42 We have had various suggestions put to us as to topics on which research is particularly required (see, for example, The Royal Society P365, and RWMAC, September 1998[38]). It would not be appropriate to comment on details of these topics now. When there is agreement on the national strategy, a comprehensive research programme should be set out, linked to milestones in a repository development programme (assuming that geological disposal is to be pursued). The DETR project on a research strategy for HLW and spent fuel disposal provides an indication of how such a research programme could be developed, and will contain information which is valuable in establishing a research programme for disposal of all long-lived wastes[39].

DEVELOPMENT OF REPOSITORY SAFETY STANDARDS

4.43 The current United Kingdom standards for the long term safety of a deep repository are those given in the 1997 Environment Agency / SEPA / DoE Northern Ireland document entitled "Disposal Facilities on Land for Low and Intermediate Level Wastes: Guidance on Requirements for Authorisation", which is known for short as the GRA. This document takes into account NRPB advice on radiological protection objectives for waste disposal[40]. For repository operation, including the whole time for which a repository is open, the HSE would apply standards based on their "Safety Assessment Principles for Nuclear Plant" (SAPS)[41], as well as the Ionising Radiation Regulations (currently being revised in the light of the 1996 European Directive on basic safety standards for radiation exposure of workers and the public).

4.44 As is evident from its full title, the GRA would not apply to a repository for HLW, nor for one for co-disposal of HLW and ILW. For this reason alone new safety standards would be needed if an integrated strategy for all long-lived wastes is put in place. More importantly, the GRA will need to be revised and expanded as a repository development programme progresses, so that it specifies in more detail the principles to be applied in repository design and the safety-related criteria to be met.

4.45 The current GRA contains only one numerical standard for long term safety: the target that the risk that an individual human being will suffer a serious health effect (fatal or genetic) from any releases of radioactive material from a sealed repository should be less than one in a million (10^{-6}) per year. It is clear that one numerical standard will not be enough. There is confusion about what the risk target means, and concern that it does not address aspects such as cumulative releases of radionuclides to the surface environment, the extent of environmental contamination and deleterious effects on organisms other than humans. It is also possible that the figure of 10^{-6} will need to be revised in the light of technological and medical developments, and changes in societal expectations.

4.46 It would also be anticipated that an expanded GRA would contain many more qualitative requirements. The majority of standards in the SAPs are qualitative "engineering principles", which reflect accumulated knowledge of what is good practice in the design of nuclear plants. The GRA should be developed in a similar way and might become as extensive as the SAPs.

CONCLUSIONS OF TECHNICAL ANALYSIS AND RECOMMENDATIONS

4.47 It is essential that the United Kingdom has a comprehensive and integrated strategy for the management of all long-lived wastes. The strategy should set out the long-term management methods for all existing wastes, for all those wastes which are certain to arise from the current civil and defence nuclear programmes, and for all those materials that are at present held in store and which are likely to be declared wastes (see also para 4.50). The United Kingdom inventory of radioactive wastes should be expanded to include all such materials, so that it becomes a better tool for use in strategy development. The strategy should take full account of plans for decommissioning reactors, so that there are no inconsistencies in timing of waste arisings and the provision of storage and disposal facilities. In developing the strategy the long-term management of nuclear powered submarines and their fuel should be considered fully and MoD policy should be brought into line with, and incorporated in, the national strategy.

4.48 There is a spectrum of possible courses of action which the United Kingdom could follow for the management of its long-lived wastes which has been identified in the course of this enquiry, from "early disposal" in a deep repository to indefinite surface storage. In an early disposal strategy a repository would be constructed as soon as a suitable site could be found and the repository would be finally sealed There is a spectrum of possible courses of action which the United Kingdom could follow for the management as soon as all wastes had been emplaced in it. We are not in favour of such a strategy because it has too many large irreversible steps, with too little flexibility and opportunity to build technical confidence. Nor are we in favour of indefinite storage of wastes on the surface: this relies too heavily on human intervention and societal stability over many centuries.

4.49 Our strong preference is for a phased approach to geological disposal, in which wastes are stored on the surface whilst a site is found and a repository is constructed, and then emplaced in a repository in such a way that they can be monitored and retrieved. The repository would be kept open while data are accumulated from the monitoring and from additional research. When there is sufficient confidence to do so the repository would be backfilled and sealed. Monitoring would then continue and it would still be possible (but difficult) to retrieve wastes.

4.50 To proceed with repository site selection and design, it is essential to know what wastes will be placed in it. Thus decisions are needed soon on whether materials which are not yet declared to be waste are to be so declared. It is possible that more than one repository will be required to take all long-lived wastes and this has to be recognised before a site selection process begins.

4.51 One or more United Kingdom deep repositories should be operational within 50 years, so that no major programme of store replacement or refurbishment, or repackaging of intermediate level wastes, has to be undertaken.

4.52 When there is agreement on the national strategy a comprehensive research programme should be set out, linked to milestones in repository development. The first phase of research would be largely generic, to assist repository site selection and design. The second phase of research would be mainly site specific. The third phase would include observations of waste packages and groundwater conditions in the repository. The current United Kingdom standards for the long-term safety of deep repositories should be revised and expanded as the repository research and development programme progresses.

4.53 Small users of radioactive materials who produce limited quantities of LLW that will decay quite rapidly to LLW should commission a study of the options for management of this waste. The options considered should include the provision of a national decay store (to allow the waste to decay to LLW prior to disposal), and direct disposal to Drigg. They should then make a formal proposal to regulators and Government for their preferred option.

4.54 Plans should be made for the establishment of a new LLW disposal facility, to open before Drigg closes. The Government should also consider alternatives to landfill disposal of less active LLW and produce a national policy that is accepted by local authorities, landfill operators, the nuclear industry and organisations outside the nuclear industry that currently dispose of LLW to landfills.

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28 *Review of Radioactive Waste Management Policy, Final Conclusions*, Command Paper (Cm) 2919, 1995. Back

29 The Royal Society, *Disposal of Radioactive Wastes in Deep Repositories*, 1994. Back

30 The Environment Agency, SEPA, Department of the Environment for Northern Ireland, *Disposal Facilities on Land for Low and Intermediate Level Radioactive Wastes: Guidance on Requirements for Authorisation*, 1997. Back

31 The Royal Society, *ibid.*. Back

32 The Royal Society, *ibid.*. Back

33 The Royal Society, *ibid*. Back

34 QuantiSci, *High-Level Waste and Spent Fuel Disposal Research Strategy: Project Status at the Half-Way Point*, report DETR/RAS/98.006, May 1998. Back

35 RWMAC, *The Radioactive Waste Management Committee's Advice on The Interim Report of the High Level Waste and Spent Fuel Disposal Research Project*, November 1998. Back

36 Health and Safety Executive Nuclear Safety Directorate, *Intermediate Level Radioactive Waste Storage in the UK: A Review by HM Nuclear Installations Inspectorate*, November 1998. Back

37 Health and Safety Executive Nuclear Safety Directorate, *ibid. Back*

38 RWMAC, *The Radioactive Waste Management Advisory Committee's Advice on the Scope and Content of the Core Scientific Research Programme on Intermediate Level Radioactive Waste Disposal. Back*

39 RWMAC, *The Radioactive Waste Management Committee's Advice on The Interim Report of the High Level Waste and Spent Fuel Disposal Research Project*, November 1998. Back

40 Doc. NRPB 3, No.3, 1-3, 1992 Back

41 HSE, *Safety Assessment Principles for Nuclear Plants*, 1992. Back

Select Committee on Science and Technology Third Report

CHAPTER 5: PUBLIC ACCEPTABILITY

THE NEED FOR PUBLIC ACCEPTABILITY

5.1 The importance of public acceptability is widely recognised: many witnesses told us that, however well founded the safety case in the view of experts, no progress would be made without public acceptability (e.g. the Environment Agency p123, Gosforth Parish (Cumbria) Action Group pp143-144). Nirex told us (p 319) the chief requirement is for a proposal which is "in a form which is workable and wins public acceptance".

5.2 Overseas the need for public acceptance has been widely recognised. Sir John Knill highlighted the relative success in Finland and Sweden where work had been undertaken on public acceptability and "an atmosphere was created within which there has been real achievements" (p 195, Q 1005). The Committee visited the US, Canada, Sweden and France, where public acceptability has also been addressed. In Canada in 1978 the Federal and Ontario Provincial Governments set up a programme to find a permanent repository for nuclear fuel waste. It was agreed that the selection of the site of the repository would not begin until after a formal public review. That review[42] concluded that broad public support is necessary to ensure acceptability of a concept, and "safety is a key part, but only one part, of acceptability. Safety must be viewed from two complementary perspectives: technical and social". Applying these criteria the Canadian review panel concluded that while safety had been adequately demonstrated from a technical perspective, from a social perspective it had not.

5.3 The technical problems in Canada are very different from our own. There is no legacy of weapons manufacture and they have elected not to reprocess spent fuel. Therefore Canada does not have the intermediate level wastes associated with reprocessing, nor the problem of managing separated plutonium. But Canada has over twenty nuclear reactors in service, has historic wastes associated with the long term operations of radium and uranium refining, and has to deal with uranium mine and mill tailings (about 200 million tonnes of these tailings have been generated since the mid 1950s). Despite the technical differences, much of the Canadian analysis has parallels in the United Kingdom. The Canadian conclusion was that work should not proceed until what the panel called "the social issues" had been further addressed. Exactly what criteria should be used to define acceptance were not specified in the report.

5.4 In the United States a good level of acceptance has been established locally at the proposed Waste Isolation Pilot Plant (WIPP) site at Carlsbad in New Mexico. Here it is proposed to dispose of "transuranic waste", primarily plutonium contaminated materials. But a lack of widespread national acceptance of waste management plans has given rise to difficulties over the transportation of the waste to the site. The Yucca Mountain project in Nevada, an evaluation of a potential repository site for spent nuclear fuel and other forms of high level radioactive waste, is considerably less advanced. The decision to embark on this work was primarily at the direction of the US Congress and has been subjected to intense opposition from the local community. There are also objections at the federal level from agencies responsible for health, safety and environmental standards. A lack of public acceptance is a major stumbling block at Yucca Mountain, where there are also outstanding technical issues.

5.5 France, which like the UK has a legacy of nuclear waste from both civil and defence programmes, has, unlike the UK, nearly 80 per cent of its electricity generated by nuclear power. The same spectrum of views about nuclear matters exists but, perhaps because of the greater dependence on nuclear power, there is less controversy about nuclear facilities and there seems a greater recognition by the public of the need to deal with waste management issues. The French government also has programmes established specifically to improve the public acceptability of waste facilities (see para 5.37).

5.6 Sweden has had an underground repository at Forsmark for short-lived low and intermediate waste in operation since 1988. By any standard this is a significant achievement, although the Swedish waste disposal problem is inherently more straightforward than our own. The Swedish Government had no weapons programme and has elected not to reprocess spent fuel and therefore Sweden does not have the intermediate level waste associated with reprocessing, nor the problem of managing separated plutonium. The public has confidence in the regulators, which may stem in part from the existence of freedom of information laws: allegations of secrecy rarely seem to be levelled at the Swedish nuclear industry and even less frequently at the regulators.

5.7 But even with the history of public confidence in the regulators, the absence of a nuclear waste legacy from past military programmes, a more straightforward waste management programme with the absence of reprocessing, and ten years' operational experience with an underground repository, Sweden has not yet gained public acceptance for a deep geological disposal facility for spent fuel.

5.8 For the last six years the Swedish Government has had in place a well-developed government programme, financed by the industry, to gain public acceptance at a local level for its nuclear waste plans. Moreover, any proposal in Sweden is subject to local referendum, which gives the local community the right of veto. On the last occasion that a local referendum was taken the proposal was lost only narrowly. It seems likely that the public confidence necessary to win approval for a proposal to build a deep repository on another site will be forthcoming in the not too distant future.

PUBLIC ACCEPTANCE

5.9 Finding publically acceptable solutions to complex technical issues is not straightforward. One witness observed that on most things the public does not think anything until it is forced to do so (Hawkes Q1488). Another witness said that "….the public should not be expected to have an opinion. There are many things for which quite legitimately the public looks to Government to make up the mind of 56 million people. Nuclear energy is a matter that is largely in Government hands and is a matter for Government decision" (Fishlock Q1489). These witnesses were clear that it is the job of those in power to take the decisions necessary for the sound management of nuclear waste. If those people are trusted by the public they will be allowed to get on with the job. Government is seeking acceptance by the majority, recognising that there may still be vocal opposition from minorities. Acceptance by the public does not imply one hundred percent endorsement.

NATIONAL AND LOCAL ISSUES

5.10 It is quite frequently the case that people will support the construction of a large facility, a major airport or large out of town shopping centre, for example, whilst also arguing that it should not be placed in a certain location e.g. "not in my back yard". The disposal of nuclear waste confronts both sets of issues: securing general acceptance of the principles underpinning an approach to the management of nuclear waste and securing local acceptance to the selection of disposal sites. Many people will go along with the concept as a general principle but object when it affects them directly.

5.11 At present it is not clear that the first prerequisite has been achieved and we discuss in the following sections some of the elements necessary to build up public confidence in a policy for nuclear waste management. These are necessary but not sufficient conditions for securing agreement at a local level: the generality must be translated into local acceptability somewhere.

TRUST

5.12 The public will accept the decisions of Government and institutions if it feels confident in placing its trust in the individuals, the organisations and all the parts of the process that lead to those decisions. The organisational structure must be one in which the public can see that its interests are well protected, and all the elements of that structure must be seen to be operating fairly. Establishing such trust is difficult and takes time: if it is lost, regaining it is likely to be even harder and to take much longer.

5.13 Surveys of public opinion about environmental issues show that the public in Britain has less trust in government scientists than in those working for environmental organisations. A MORI poll in 1997 on environmental attitudes showed that the proportion of the public expressing "a great deal" or a "fair amount" of confidence in scientists working for Government was 44%, whilst the corresponding figure was 47% for scientists working in industry and 83% for scientists working for environmental groups.[43]

5.14 In 1998, the Royal Commission on Environmental Pollution's 21st report[44] commented that "there is nevertheless much evidence that trust has been eroded. When major and widely-publicised issues arrive (such as … the disposal of waste from the nuclear industry), public opinion about the nature and extent of the risks they pose may turn out to be at sharp variance with the assessments that have been made by those with official responsibility for environment protection". In general, the public has a propensity to believe statements from environmental organisations that there are significant risks and to disbelieve Government statements that risks are negligible. Professor Wynne (University of Lancaster) told us that expert bodies had not taken the institutional trust dimension seriously enough (P 411).

PERCEPTION OF RISKS

5.15 Dr Pidgeon from the University of Wales explained that disposal of nuclear wastes has almost all the negative characteristics as far as its perceived risks are concerned. The risks are not voluntarily accepted at the level of the individual; the benefits and the costs are not seen clearly alongside each other; the nature of some of the risks (e.g. cancer) have a particular dread factor; and the degree of risk is subject to uncertainty, to which the public has a particular aversion (Q 872).

5.16 Although it is a relatively new field of study, there has been considerable academic debate recently over public tolerance or acceptance of different types of risk. Some of this general discussion was rehearsed in the evidence we received, although most comments focused on the specific issues raised by the long time scales involved. The UKAEA told us that there was substantial agreement on the standard of safety acceptable, and that safety now and in the future can be defined quantitatively in terms of risk (p 315). However, the BGS (p 32) said that it is unreasonable to expect that an assessment of risk made now will remain unchanged.

5.17 The National Radiological Protection Board (NRPB) advocates a risk "constraint" of one in a hundred thousand per year for any individual who could be exposed to radiation from a closed waste disposal facility. The risk referred to is that of the individual incurring fatal cancer or passing on to his or her children a serious hereditary defect. NRPB considers that 1 in 100,000 is the maximum risk which should be tolerated from a waste repository and further recommends the use of a risk target of one in a million per year in repository design. "The (1 in a 1,000,000) design target represents a level of individual risk which is widely regarded as acceptable" (NRPB p218). RWMAC (p 258), Nirex (p 325), BNFL (p 38), UKAEA (p 315), the DETR (Q 56), and others in the nuclear industry all defended the one in a million (10^{-6}) risk level.

5.18 Most of those who supported the 10^{-6} criterion argued that it would continue to be acceptable. Some witnesses, however, argued that a change of attitude may well occur if current trends continue. "As the hazards of life have diminished in industrialised society, reflected by increasing life spans, the tolerance of risk, particularly risk associated with technology, has diminished" (The Royal Society, P367). Dr Loomes made a similar point (Q 878). Greenpeace said that we know nothing about the view that future generations might take; "all we do know is that the levels of radioactivity which are deemed to be acceptable during the lifetime of the nuclear industry have progressively declined" (Q 434).

5.19 We received much evidence on the public's view of risk and the need to put figures in perspective. For example Gosforth (Cumbria) Parish Council noted that a rational assessment of risk by the public would be difficult when the Government accepted smoking (1 in 200 risk of death from smoking related disease), but legislated against selling beef on the bone (p 149) (where the risks of contracting CJD are likely to be much less than 1 in 500,000 but are less well characterised).

5.20 QuantiSci (pp 245-246), the Health and Safety Executive (p 162) and Golder Associates (p 141) said that numerical estimates should form only part of the risk evaluation and should be treated with caution because very few people have sufficient understanding of what the numbers represent. Similarly, the DETR said that risk estimates should form only part of the safety case, although they were useful in shaping engineering concepts (Q 55). Dr Couples warned that lumping performance parameters together could obscure the significance of a single element which might be critical "and would not be recognised by someone who did not have a complete grasp of the entire model…and who would?"(pp 98-99). Professor Wynne argued that abstract figures of risks like these are not meaningful to the public. Cumbria County Council and others said that risk assessments of storage or disposal will need to be more effectively explained and made accessible to a lay audience (e.g. pp104, 113).

5.21 Some of the characteristics that affect public perception are easier to change than others, but the idea that "there is a public perception out there" that can be easily changed "by providing information or a publicity campaign, just does not work" (Pidgeon Q 864). Indeed according to Dr Loomes from the University of Newcastle "were the Government to find the right way of putting across…the truth about these things" there would still be a difficulty because "in many of these sorts of areas there is no obvious and uncontested truth" (Loomes Q864). Nonetheless perceptions can change: "we observe that people's perceptions change very rapidly in relation to events such as media stories" (Dr Pidgeon Q865).

5.22 Dr Loomes told us how the public attitude to nuclear risk tended towards the catastrophic: "I think many members of the public suspect that there is a very substantial possibility of human error, negligence or something of the kind which may be left out…. The other possibility is that members of the public may just have very different values about the nature of the losses that are involved" (Q 851). Dr Loomes said that public misconceptions should be identified and genuine public values should be taken into account when framing policy, but admitted that this was extremely difficult to do (Q 851).

OPENNESS AND TRANSPARENCY

5.23 A key requirement in any programme intended to increase public trust is openness. Many witnesses expressed the need for openness on regulatory matters; for example the Scottish Environment Protection Agency (SEPA) was cited by the National Steering Committee of Nuclear Free Local Authorities as a good example of openness (Q 403-404). SEPA thought that its present structure, where most meetings are held as open fora, allowed open, transparent decision making and enabled the public to "participate meaningfully in this process"(p 276). The Environment Agency told us that most of its regional and local area committees were open to the public and, although its main board was not, a summary of its business was published on the Agency's Web pages (Q 615). The Health and Safety Executive told us that the public was involved in all of its major inquiries into nuclear sites, and inspectors report regularly to representatives of the public at local liaison committees (Q 694-696).

5.24 Various witnesses said that the nuclear industry is not open enough, despite improvements in recent years. Copeland Borough Council described how they had been unable to obtain some information on the Nirex proposal until it reached the RCF Public Inquiry. Others described to us the need to ensure scientific papers are published and subject to peer review (eg Greenpeace Q 497). Nirex acknowledged that it had been severely criticised in the past and that their aim in future was to be seen as not secretive (Nirex Q1396). There were criticisms of the Nuclear Installations Act, which contains no provisions for HSE to consult the public on variations of nuclear site licences (eg pp221-222), and of the Health and Safety at Work Act, which only allows HSE to release information when an industry organisation gives its permission. An example of the restrictions under the latter Act was when UKAEA felt that an HSE inspector's report would be commercially damaging and HSE could not make the report public until many months after it had been written[45]. There was considerable criticism of the secrecy of MoD on nuclear waste matters (eg CND, pp53-55)

5.25 We were told in Sweden that their tradition of freedom of information, dating back to 1766, had established a basis of trust whereby the public understood that it could always obtain the relevant information if needed. In practice this meant that rarely did members of the public seek information themselves; they placed their trust in their elected representatives and regulators to do what was necessary on their behalf. Freedom of information is a broader subject than we wish to address here but it is clear that where people are concerned about risks, secrecy can be counterproductive.

5.26 There should be a general presumption of disclosure, openness and transparency. This is a necessary condition for achieving public trust. The RCEP[46] concluded that "bodies setting environmental standards must operate in an open and transparent way. There must be full publicity for their existence, their terms of reference, the decisions they take and the reasons for them. There must be adequate opportunities for those outside an institution, especially those with a particular interest in the given decision, to contribute fully to the decision making procedure".

5.27 Openness is not without cost. In matters such as the selection of a prospective site for storage or disposal of nuclear waste we were told that the fundamental problem underlying a commitment to an open, honest and transparent process is planning blight (Grant Q1276). This difficulty cannot be avoided: it is part of the price of openness (see paragraphs 5.36 and 5.43).

THE MEDIA AND THE SILENT MAJORITY

5.28 We briefly examined the influence that the media has in providing information and influencing public opinion. Where people have no personal experience, for example of radioactivity, undoubtedly the media can play a role in forming public opinion (Hawkes Q1465). Normally the newspapers and television are the first places where people learn about these issues, and the way in which the stories are couched can set the development of public attitudes.

5.29 Nuclear waste was the subject of some considerable media attention during the course of our enquiry. There was reporting on clean up plans for the Dounreay waste shaft and an incident leading to the closure of the reprocessing facility there; on Britain's acceptance of a small amount of nuclear waste from Georgia in the former Soviet Union; and on pigeons that have spread radioactive material from the Sellafield site. None of these stories showed the nuclear industry in a favourable light. The Royal Society commented that the media tend to give a story a sensational angle (Q 910, Q 912), but witnesses who spoke to us about risks said that the media were only part of the process through which public perceptions become formed (Pidgeon Q 865). One witness considered that, on many issues where there really is no public opinion, the reporter's tendency is to take the views of a small number of people who are talking loudly as representing a large number of people with more moderate opinions (Hawkes Q1464). Mr Hawkes explained that a pressure group that specialises in a particular subject has a well-formed opinion that is generally quite well argued with supporting data (Q 1645).

SOME WAYS OF BUILDING PUBLIC TRUST

5.30 We examined one area where the public perception of risk and the action that should be taken seemed at odds with the scientific assessment: the experience of Shell in the disposal of its Brent Spar oil rig in the North Sea. The conclusion of both the company and Government experts was that the preferred option for decommissioning the rig was deep-sea disposal. But a campaign by Greenpeace and others in the United Kingdom, Denmark, the Netherlands and Germany led to the abandonment of this policy in favour of an alternative use.[47]

5.31 Following the abandonment of its original proposal (still considered by many to represent the best environmental option), Shell established a process whereby the company could open up a discussion with interested parties. Mr Faulds, from Shell, observed that the "traditional decide, announce, defend" process had now changed to "show me" (Q 1298), where explanation and discussion of the options preceded the decision. He explained that it is not practical to consult directly with the public in a wide sense on a complex technical issue (Q 1305), but a means had to be found to assess views. Shell brought together balanced audiences which were not dominated by industry, green or other groups: they included political interests, unions, the church, academic interests etc, with no one group dominant (Q 1319). Shell was not seeking to establish a consensus (Q 1309) but was asking the group what criteria it would use in making a judgement on the relative priority of the issues put before it. The company's role was to listen; it still had to make its own decision. "We do not think that either industry or Government can abdicate its responsibilities for making decisions" (Mr Faulds, Q1306). The process described by Mr Faulds, which was put in place after Shell had been forced to abandon its original plans for Brent Spar, is an example of attempts to build an understanding of the issues with key sections of the public.

5.32 The technique used by Shell is only one of those now being tried. The Cabinet Office has formed a "Peoples' Panel"[48], there has been one consensus conference and another is planned, and other countries have used citizens' juries and deliberative polls. As the RCEP point out in their 21st report[49], when judgements are made about environmental issues "decisions must be informed by an understanding of people's values". None of the new techniques is a means of achieving compromises between extremes or of taking decisions. They enable constituencies of opinion formers to be built which have a deeper understanding of the issues, and provide decision-makers with valuable information. National issues, such as the management of nuclear waste, must remain matters for Government decision.

THE PLANNING SYSTEM

5.33 We discussed in paragraphs 5.10-5.11 the distinction between national and local issues. If handled with sensitivity, enough confidence in Government's chosen policy for nuclear waste management may, over time, be established at the national level. Such national acquiescence in the overall policy is a necessary condition to proceed but agreement must also be reached locally on specific site proposals.

5.34 Many witnesses hoped that the technique for building public trust could establish a consensus which would overcome local planning difficulties. The RWMAC agreed with the findings in the POST report that the Town and Country Planning procedures created great difficulty for repository development (p 251). The BGS (p 31), the UKAEA (QQ 244-251), the Environment Agency (Q 548) and other witnesses told us that the site selection process must seek a consensus view by involving the public, regulatory and advisory bodies, academia and relevant learned societies.

5.35 But in essence the planning system is designed as a process of dispute resolution. At its heart it is almost inevitably adversarial when dealing with local issues on which there are genuine differences of opinion amongst industry, Government, local authorities, pressure groups and local residents. For the local planning process to function well, a clearly stated and broadly accepted Government policy must be in place at the outset. It is certainly not appropriate, as Professor Grant said, for a planning inquiry inspector to try to make national policy for Government or Parliament in the light of the evidence given at a local public inquiry (Grant, Q1233). That does not mean that the inspector should stifle all debate. As Professor Grant pointed out, participants at local inquiries feel cheated if they are unable to question some of the fundamental assumptions on which the proposal is premised (Q 1234).

5.36 We discuss in chapter 6 the improvements to the planning system described by the DETR (Q 58)[50] which include key points designed to improve the planning procedures for major infrastructure projects. These policies, when implemented, have the potential to achieve significant improvements. Nevertheless, the planning inquiry will remain the point of local assessment, and cannot be confined to details of policy implementation. The final decision on a site will rest with the Secretary of State based on the Inspector's report.

ASSOCIATING RISKS AND BENEFITS

5.37 We discussed earlier the steps needed to build trust and establish agreement to - or acquiescence in - a national policy. To achieve local agreement more is required. Many witnesses, and in particular those representing people close to the proposed Nirex site near Sellafield, argued that compensation should have been given so as to offset the fall in land and house prices described as "nuclear blight". The Gosforth Parish Action group described the nuclear blight in their area: new industry was reluctant to set up nearby and one food firm had to close because customers elsewhere in the UK refused to buy products coming from near Sellafield (p 145). From the evidence of Copeland Council (p 93) we conclude that, while the local community there stood to gain indirect benefits from accepting a waste facility, for example in increased employment opportunities and in the provision of services to the contractors, much of the local electorate would have seen little direct benefit. There is little motive for them to support any proposal to site a repository in their locality.

5.38 Dr Loomes said that members of the public were more likely to be comfortable with risks if they were familiar with them and if they could also see direct benefit from taking them (Q 851). QuantiSci called for community financial trusts, infrastructure improvements, local and regional development preferences and local tax deductions (p 245). Sir John Knill described the benefits that could be made available to a community that agreed to host a site (Q 1031). In France the Committee was told the French Government offered the equivalent of £0.5 million per year during the investigation period to communities that volunteered to host a nuclear waste repository and that £6 million was available per annum until the year 2006 for the communities actually chosen. Other witnesses (including Nirex, p324, Sir Richard Morris, p210, and RWMAC, p254) expressed support for measures in countries such as Sweden, Hungary, France and Canada where communities are asked to volunteer as possible sites for a waste repository. Some were given some form of financial inducement.

5.39 With a transparent and open system for decisions on the location of facilities it is inevitable that blight will occur. Changes underway to the planning system will speed up the process and will minimise blight[51], but it will nonetheless occur. Government should do more to create a linkage between the costs that a local community might have to bear and benefits that it can receive from any nuclear waste management activity. These benefits might be in the form of specific measures to improve the local infrastructure, to compensate for increased road traffic or loss of other business, or it might take the form of more direct assistance in the form of community services.

CONCLUSIONS ON PUBLIC ACCEPTABILITY

5.40 Public acceptability of a national plan for the management of nuclear waste is essential, but achieving it will be difficult. The potential risks to human health and the environment are not easily expressed in ordinary terms and the benefits of managing waste are not clearly related to these risks either at national or local level. Within many groups in society there is an aversion to the uncertainty inherent in long-term risks and a lack of trust in some of the organisations involved in regulating such risks. Some groups have a single minded adherence to their own viewpoint such that they will not accept a contrary conclusion, however democratically arrived at (Greenpeace Q470). Because of these differences in attitude the establishment of broad public trust in all aspects of the process is vital.

5.41 Social science research has provided some insights into how people perceive risks. It has shown that there is no one "public perception" or public opinion, and that perceptions and opinions do change with time. But there is no simple means of changing them by, for example, providing information in different ways or through different media.

5.42 Much emphasis is placed in the evidence given to us upon openness and transparency in decision making. These are seen as essential to the task of seeking to gain public acquiescence, acceptance and, possibly, even support for a national programme on nuclear waste management: where there are concerns about risks secrecy is counterproductive. We concluded that it is necessary to be open and transparent but further mechanisms are needed to include the public, or rather the various groups within it, in decision making. Some new methods are currently being tried which do not give undue preference to minorities at the expense of the "silent majority".

5.43 The steps outlined above, based upon the recognition that the attitude of the public is vital, have been lacking in previous attempts to develop policies for the long-term management of nuclear waste in the United Kingdom. There has been an over reliance on the nuclear industry to establish or change public views, to formulate its preferred policy and to gain public acceptance of it. Past approaches, which could be characterised as "decide, announce, defend", have not worked. Local planning inquiries have become the focus of major public debate on the nation's policy for nuclear waste disposal, a role for which they are singularly ill suited. A national policy must be established with which the public is broadly content. This should be demonstrated and underpinned by parliamentary endorsement, as we will discuss in the next chapter.

5.44 With a national policy in place, there still remains the even more difficult task of ensuring that those most affected must have confidence in the integrity of the planning inquiry. They must also be reassured that they will not be the losers, in economic terms, from the selection of a local site. Supporting measures might include regional infrastructure improvements, support for local authority services, or other measures specifically to address the difficulties of individuals selling property.

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42 Report of the Nuclear Fuel Waste Management and Disposal Concept, February 1998, Canadian Environmental Assessment Agency. Back

43 Market and Opinion Research International (MORI) 1997, Business and the Environment 1997. Attitudes and Behaviour of the General Public. August 1997. Back

44 Royal Commission on Environmental Pollution 21st Report "Setting Environmental Standards" October 1998. Back

45 HSE Inspector's Report on the fuel cycle area at Dounreay, released 15 June 1998. Back

46 Royal Commission on Environmental Pollution 21st Report "Setting Environmental Standards" October 1998. Back

47 Decommissioning of oil and gas installations, February 1996. Back

48 The People's Panel; The Service First Unit, Cabinet Office. Back

49 Royal Commission on Environmental Pollution 21st Report "Setting Environmental Standards" October 1998. Back

50 Modernising Planning 15 January 1998. Back

51 DETR, January 1998, Modernising Planning. Back

Select Committee on Science and Technology Third Report

CHAPTER 6: POLICY DEVELOPMENT AND ORGANISATIONAL ISSUES

POLICY DEVELOPMENT

Present policy and views of witnesses

6.1 Present United Kingdom policy is to dispose of ILW in a deep repository and to store vitrified HLW for about 50 years to allow it to cool sufficiently before its disposal[52]. Most LLW is disposed of (primarily to Drigg and also to approved landfills) and the remainder stored pending the availability of a deep repository. There are some materials that are held in store pending decisions on how or whether they are to be recycled or re-used in the future; some of these may, in due course, be declared to be wastes (eg spent fuel from nuclear-powered submarines; plutonium and uranium separated during reprocessing, see Chapter 7).

6.2 Several witnesses, including Cumbria County Council (pp 102-103) and the National Steering Committee of Nuclear Free Local Authorities (pp 218-219), called explicitly for a review of national policy, with wide ranging consultation. Other witnesses included such a policy review, or consultation on policy, or both, in their proposals for a new organisational structure for nuclear waste management (see, in particular, the nuclear industry evidence PP 280-285 and the RWMAC evidence PP 357-363).

6.3 There was agreement amongst many of our witnesses that there is a need for a policy which is stated more clearly, which commands widespread support and which has parliamentary endorsement. For example, BNFL (p 36), British Energy (p 25), Sir John Knill (ex Chairman of RWMAC, p 196 and Q 1005) and Sir Richard Morris (ex Chairman of Nirex, Q 1037) all called for a clear declaration of Government policy. Dr Fisk of DETR said that a solution which commanded "very wide consensus" was the only way forward (Q 6). Dr Hodgkinson of QuantiSci agreed, saying that it is necessary to start in such a way that "there is cross-party support, …wide acceptance that the programme should go ahead and that it represents the best national interest". His opinion was that "a new policy would stand or fall almost the day it is announced" and that "if people feel they have trust in the new strategy framework from the start, that would continue" (Q 164).

6.4 Views were also expressed that, hitherto, there has been only intermittent Government commitment to policy. RWMAC highlighted this, together with inadequacies in the legislative framework, as two reasons for the failure of the Nirex programme (P 361). Sir Richard Morris concurred: "We need leadership from Government on a continuous basis for a project which will be potentially controversial for the next, say, 100 years. Parliament must back the project and the process and organisational and management structure, perhaps through an annual report to Parliament" (Q 1037). The British Geological Survey (p 30) and the Joint Trade Unions (p 190) noted the same problem.

Our views

6.5 We believe that the present policy is flawed and fragmented. It does not identify all existing and potential wastes. It does not set out in enough detail the means by which all long-lived wastes are to be managed over the next century and beyond. It does not make it clear that more than one deep repository may be needed (see Chapter 4).

6.6 We have concluded that the Government should develop a fully comprehensive policy for the long-term management of all United Kingdom nuclear waste. This proposed policy should be put to Parliament for debate and decision, in the form of a Bill, so that the adopted policy has explicit parliamentary endorsement and statutory authority. At appropriate intervals, when major milestones in implementation are reached, the policy should be put to Parliament again. Similarly, if scientific or other developments occur which make a large change in the policy desirable, this change should be subject to parliamentary debate. In this way enough assurance can be provided that the chosen methods for the long-term management of nuclear waste will be carried out, over the decades (perhaps centuries) required.

6.7 It is essential that, before the policy is put to Parliament for approval, there is substantial public consultation. We recommend this take place on a Green Paper embodying the proposals which the Government is minded to put to Parliament, having studied our report. The consultation should be designed to involve as wide a range of people across the country as is feasible. The Government should approach this consultation with the objectives of:

(1) informing the public of the problem of nuclear waste and of the imperative need to deal with it;

(2) discussing with the public the solutions open to the Government;

(3) seeking views on the institutional framework proposed to handle the processes of decision-taking and implementation including, in the case of deep repositories, the process of site selection.

When the consultation is completed the Government should present to Parliament a full statement of the policy for which they seek approval, together with a report on the outcome of the consultation. These could be in the form of a White Paper. They would be followed by the Bill to establish the new policy.

6.8 Those consulted should include Government departments, regulatory agencies, the nuclear industry, environmental pressure groups, trade unions, local authorities and other interested groups within the public. We do not wish to prescribe the consultation process in detail but we note that the emphasis should be on dialogue, moving forward and building trust (see Chapter 5).

6.9 Our own opinion is that the best policy, indeed the only realistic policy, is a phased approach to geological disposal of long-lived wastes. This would combine surface storage with emplacement of wastes in one or more deep repositories in a monitored and retrievable way. The repository would be backfilled and sealed when there is sufficient confidence to do so; after this monitoring could continue and it would still be possible, but more difficult, to retrieve the wastes (see Chapter 4). We recognise that others may not accept our view immediately, particularly if they have not been consulted about how the policy is to be implemented. Consultations on the nature of the repository site selection process are especially important; we provide suggestions on this process later in this chapter (see paras 6.29-6.38).

ORGANISATIONS AND THEIR RESPONSIBILITIES

6.10 Under current institutional arrangements radioactive waste management policy is developed by Government departments, led by DETR, who receive advice from, in particular, RWMAC. The main regulators are the Environment Agency, SEPA and HSE. The two principal disposal organisations are BNFL, which owns and operates Drigg, and UK Nirex Ltd. The shareholders in Nirex are BNFL (which has about 75% of the shares), British Energy and UKAEA; the Secretary of State for Trade and Industry holds one "golden share" and is represented on the Nirex board (P 279, Q77). Nirex operates via loans from its shareholders, which are to be repaid by providing disposal services. MoD now has a full working relationship with Nirex, and contributes funding and expertise to it, but is not a shareholder represented on the board (Q 298). Nirex has responsibility for disposal of ILW and the LLW which is to go to a deep repository. No organisation has yet been made responsible explicitly for disposal of HLW. (BNFL are responsible for storage of HLW and are regulated by HSE and the Environment Agency.)

6.11 There are likely to be some changes to the current organisational arrangements when the Scottish Parliament and the Welsh and Northern Ireland Assemblies are in being. We have not examined the possible impact of devolution. Our recommendations are made for the United Kingdom as a whole and we leave it to others to interpret the relevant legislation in the future devolved situation.

Views of witnesses on advisory and implementing bodies

6.12 None of our witnesses believed that the present organisational arrangements for nuclear waste management are satisfactory. Of the changes suggested the smallest was to alter the name of Nirex (e.g. Professor Williams, p336), and the largest was to set up a new company or agency to replace Nirex and a new independent body to oversee it (e.g. the Royal Society P 366, NERC p 225, CORE p 107, the Geological Society p 137, Friends of the Earth p 132, p 279 and P 319, and Gosforth Parish Council pp 144-145). There were also suggestions to change the remit and composition of RWMAC (e.g. Sir John Knill, Q 1019; Sir Richard Morris, Q 1037; the National Steering Committee of Nuclear Free Local Authorities, p 222; Friends of the Earth West Cumbria and North Lakes, p 132). The most detailed proposals for a new organisational structure were put forward by RWMAC itself (PP 357-363), the civil nuclear industry (PP 280-285) and QuantiSci (pp 243-248 and PP 355-357). These proposals all assumed that geological disposal would continue to be the chosen method for the long-term management of nuclear waste. The main features of the proposals are shown in Table 2.

TABLE 2 FEATURES OF EXISTING AND PROPOSED ORGANISATIONAL ARRANGEMENTS FOR MANAGEMENT OF LONG-LIVED WASTES

Proposer	Government and Parliament	*Regulators*	*Advisory Bodies*	*Disposal Organisation*
Existing	DETR responsible for policy, with MoD and DTI No formal involvement of Parliament	HSE, Environment Agency, SEPA Responsible to Parliament via DETR Ministers Funded by levies and charges on waste producers	RWMAC (reports to DETR Ministers) NuSAC (previously ACSNI, reports to HSC)	UK Nirex Ltd, responsible to its nuclear industry shareholders, funded by loans from shareholders and by MoD Deals with ILW and LLW
QuantiSci	DETR responsible for policy, monitoring progress and ensuring results achieved Parliament to set statutory framework and approve disposal concept and site selection	As now, but with strengthening of Environment Agency. Regulators to work with new Commission on Radioactive Waste (CRW) to assess technical aspects of repository safety case at time of licensing	CRW to set programme for repository development, set siting methodology, review NWDC work, carry out R&D and communicate with all stakeholders. To have wide representation and a professional staff	New Nuclear Waste Disposal Corporation (NWDC) to develop, construct and operate repository, under guidance and supervision of CRW Funded and managed by industry To deal with all long-lived wastes
RWMAC	DETR to develop and promote legislation, and set up Planning	As now	New Statutory Repository Board: a facilitating body to advise government throughout repository planning and development, to monitor work of Executive Disposal	New Executive Disposal Company to deliver successful repository project.

	Inquiry Commission for site selection Parliament to pass Act to set up Statutory Repository Board and Executive Disposal Company and set out need for Quality Plan		Company, to conduct independent technical reviews. Would report to Parliament at key stages	Industry funded, with broader board membership than Nirex
BNFL, Nirex, British Energy, UKAEA	Government to state policy, set up Advisory body, establish site selection process, endorse choice of site No involvement of Parliament unless legislative changes required (eg on planning)	As now but with better co-ordination between HSE and environment agencies	New Advisory Body to make recommendations to government on site selection criteria, commissioning research as necessary, to oversee site selection process, to facilitate consultations and to ensure adequate review of Disposal Company programme. Limited nuclear industry involvement	New Disposal Company, funded by waste producers, with a culture of openness and transparency, with broader board membership than Nirex

6.13 QuantiSci propose that there should be a "Commission on Radioactive Waste (CRW)" with an "Executive" of technical and social science staff (pp 243-248 and pp 243-248). The CRW would: carry out consultations; establish a methodology for siting a repository and oversee its application; ensure that there is liaison between the repository developer, regulators, planning authorities and others; advise DETR and Parliament as to the progress of the programme; and act as a local negotiator at potential repository sites. The CRW would be a facilitating organisation, charged with implementing long-term national policy and acting in the best public interest, and would also carry out R&D (by sub-contracting work) (Q 169). Members of the CRW would be drawn from the science and technical community, the health professions, environmental organisations, trades unions, public interest groups and the nuclear industry. The CRW would be independent of the nuclear industry but funded by a levy on it, via a segregated fund.

6.14 RWMAC favour the creation of a "Statutory Repository Board" which would be, in essence, a facilitating body (pp 248-263 and PP 357-363). The Board would be charged with promoting the implementation of national policy and its primary role would be to advise Government throughout the process of planning and developing a repository. This process would be set out by Government in a "Quality Plan", which contained the programme with milestones. The Board would be made up of independent experts in appropriate disciplines. It would ensure openness and transparency in repository planning and development, advise on the detail of the site selection process specified by Government, and undertake technical reviews. The Board would report to Parliament at key stages, particularly during site selection (P 359).

6.15 BNFL, Nirex, British Energy and UKAEA propose that an "Advisory Body" be set up which is independent of the nuclear industry and which has a broadly-based membership (PP 283-284). The primary function of the Body would be to provide advice to Government and the composition of the Body might change as the nature of the required advice changed. The Body would consult widely on the repository site selection procedure and criteria, and would commission research to assist with site selection. The Body would report to Government on the extent of consensus and identify topics which need to be addressed in future (P 284).

6.16 In the framework suggested by QuantiSci there would be a second new organisation. This would be a "Nuclear Waste Disposal Corporation" (pp 243-248 and PP 355-357), which would be an implementing body, entirely funded and managed by the nuclear industry, and which would accept and dispose of all relevant wastes. The NWDC would be responsible for researching, developing, building, operating and closing a repository, and gaining all the necessary regulatory and planning approvals. It would be overseen by the CRW.

6.17 RWMAC propose that there should be an "Executive Disposal Company" which has the role of delivering a successful repository project, in accordance with the Government programme, additional advice from the Statutory Repository Board, and the requirements of regulatory and planning authorities (PP 357-363). The majority of the board of the Company would be independent of the nuclear industry. The Company would carry out site investigations, safety assessments of short-listed sites, and R&D, including the construction of an RCF. It would obtain all the necessary regulatory and planning approvals and would construct the repository.

6.18 BNFL, Nirex, British Energy and UKAEA also propose that there should be a new "Disposal Company" which would be funded by the waste producers (P 284). The Company would have a culture of openness and transparency. Its board would be composed of people from a wider range of backgrounds than the Nirex board and there would be fewer representatives of the waste producers. The Company would implement the site selection process which had been established by Government (based on the recommendations of the Advisory Body), carry out site investigations, commission R&D and offer the results for peer review, and design, build and operate the repository, obtaining the necessary regulatory and planning approvals (PP 280-285).

Our views

6.19 The proposals made above deal only with repository site selection and development. There is a need for a new body which has a wider remit, and the authority and permanence required to oversee the national nuclear waste management programme. We recommend that a 'Nuclear Waste Management Commission' be set up, eventually by statute, with a professional staff. This would be analogous to the Health & Safety Commission (and HSE), but with a much more specific remit and on a much smaller scale.

6.20 Initially, the Nuclear Waste Management Commission could be set up without legislation, with the task of undertaking consultations on a Green Paper covering a comprehensive policy for the management of all long-lived wastes (see paras 6.5-6.9), and undertaking any associated technical and economic analyses. It would report its findings to Government which would use them in formulating the policy to be put to Parliament in the form of a Bill for debate and decision (see para 6.7).

6.21 The Bill would establish policy and give the Commission powers to undertake its subsequent role. Its role would be, in essence, to make sure that the policy endorsed by Parliament is implemented. It would include carrying out research and making arrangements for research to be carried out, undertaking consultation on means to implement policy, and providing information. The workings of the Commission would be as open as possible, with a presumption that everything it produces will be published.

6.22 Members of the Commission would be appointed by the Secretary of State after appropriate consultation, and would be drawn from a wide range of backgrounds to ensure that no one point of view was dominant. The Commission's staff would include people qualified in the physical, biological and social sciences.

6.23 The Commission would report annually to the Secretary of State, who would place its report before Parliament. At appropriate intervals debates would be held on the Commission's reports; regular, explicit parliamentary approval is essential.

6.24 If, as we favour, it is decided to embark on a phased approach to geological disposal (see Chapter 4), a second body will be needed, of the type suggested by QuantiSci, RWMAC and the nuclear industry. This would be a 'Radioactive Waste Disposal Company', with the remit to investigate a small number of potential repository sites, to select the preferred site (or sites) and to design, construct, operate, monitor and eventually close the repository (or repositories), conducting R&D as necessary. The company should be able to retrieve the waste if this became necessary. This would be a nuclear industry organisation, structured so that it requires approval from the Commission for its work programme. Government involvement in the Company would be only via the publicly owned parts of the nuclear industry (BNFL, UKAEA and MoD). The Company would work in as open and transparent a way as possible, restricting confidentiality to the absolute minimum consistent with commercial operation.

6.25 It seems sensible, for the present, to maintain Nirex to fulfil two roles. One is to advise the nuclear industry on the acceptability of waste conditioning and packaging proposals (the issuing of 'letters of comfort'). The other is to help the United Kingdom to keep abreast of international progress in repository R&D and to maintain expertise. Once the new organisations are established, the roles of Nirex should be subsumed by them. Its "letters of comfort" role should be undertaken by the nuclear industry and its regulators. The Commission should be responsible for monitoring international progress and maintaining expertise.

6.26 When the Commission is set up RWMAC's role in advising Government on the management of nuclear wastes will no longer be required and the Committee should be disbanded.

RESEARCH CO-ORDINATION AND CONTINUITY

6.27 In our proposed new organisational framework the Nuclear Waste Management Commission would be responsible for co-ordinating all United Kingdom research on the long-term management of nuclear waste. The main organisations which would sponsor research would be the Commission itself and, if geological disposal is pursued, the Radioactive Waste Disposal Company; the latter would need approval from the Commission for its research programme.

6.28 It is important that there is no loss of expertise or continuity while consultations on policy are underway and before the Commission is given its powers by statute. We suggest that during the consultation period the Commission takes over from the various DETR committees the role of co-ordination of research and that it has the task of ensuring that records of past research findings are completed and are preserved. This applies particularly to the research sponsored in the past by Nirex, but there is also a need to safeguard the findings of past regulatory research programmes.

SITE SELECTION AND THE PLANNING SYSTEM

6.29 No new national policy could be implemented unless it has the acceptance of those who would be most affected by it, namely those who live and work near proposed repository sites. It will be difficult to gain the acceptance of local authorities and local environmental pressure groups for a national policy unless it is clear how their views will be taken into account in implementing it and, in particular, unless it is clear what say they will have in the selection of repository sites (see Chapter 5). (We assume that the new United Kingdom nuclear waste management policy will entail the construction of one or more deep repositories (see Chapter 4). Such difficulties would arise with similar intensity if the new policy entailed construction of major centralised surface storage facilities, especially if these were to be outside the boundaries of current nuclear licensed sites.)

6.30 It would be for the Nuclear Waste Management Commission (see paras 6.19-6.23) to propose a site selection process, after the necessary consultations, and to submit it to Government and Parliament for approval. We set out here the conclusions we have reached about the main features of an appropriate process and how it would fit within the planning system. Our conclusions take account of the Ministerial policy statement Modernising Planning (DETR, 1998) and draw particularly on the evidence of Professor Grant, Mr Joyce and Mr Piatt (PP 341-343 and QQ 1212-1293).

6.31 We suggest that the first phase of site selection be carried out by the Commission, which could contract independent professionals if necessary (as proposed by RWMAC, see p254). This phase would consist of establishing qualitative criteria and using them with desk studies to identify a "long list" of, say, 15-20 potentially suitable sites. The criteria at this stage would be primarily, but not exclusively, geological and hydrogeological (QuantiSci p 245, RWMAC pp 254-256). A short list of sites for possible field investigation (including the drilling of deep boreholes) would then be derived by comparing the sites on the basis of a number of attributes. The attributes and the comparison method, including the weightings for the attributes, would be established by the Commission and made public. The final list of sites for field investigation would be derived by consultation or by using a volunteering approach (see Chapter 5). It would be the Commission that handled the consultation or 'volunteering' process. We envisage that volunteering would be on the basis that the local community could not withdraw the site once field investigations had begun, and that the final decision on a site would be for Government (see below).

6.32 Blight would occur when the short-listed sites are named (QQ 1274-1275). It would be appropriate to offer some form of compensation to mitigate this 'nuclear blight' and to enable people to derive some form of benefit from hosting a repository (see Chapter 5). Government should consider how this is to be achieved, bearing in mind that generosity may succeed but parsimony will not.

6.33 The field investigations at the short-listed sites would be carried out by the Radioactive Waste Disposal Company (see para 6.24), overseen by the Commission. All the results of the investigations would be published, for scientific peer review, and would be reported to the local populations and their elected representatives in a form intended to be comprehensible to non-experts. If it became clear during the investigations that a short-listed site is not suitable, the Company would inform the local community and withdraw it. The quantity of waste which a site could hold will have been considered throughout the derivation of the long and short lists but it will probably only be during site investigations that capacities can be determined with any accuracy. By the end of the investigations it must be clear whether it will be sufficient to construct one repository or whether more are required.

6.34 When sufficient data were available, the Company would identify its preferred site or, if more than one repository is needed, sites. The selection would take place within the framework of a formal environmental impact assessment, in which all the short-listed sites are compared, in compliance with European Directive requirements to consider alternatives (Q 1237). The Commission would ensure that the selection process is open, transparent, reasonable and robust, but would not endorse the chosen site or sites.

6.35 We believe that Parliament should be involved at this stage, as envisaged in the parts of Modernising Planning that deal with major infrastructure projects, and as suggested by our witnesses on planning matters (PP 341-343, QQ 1262-1264). One approach is to establish a procedure modelled on that in the Transport and Works Act 1992 for schemes of national significance. Under such a procedure the Company would make an application to develop a preferred site, for approval by Ministerial order. Because the scheme would, by definition, be of national significance, the Secretary of State would refer the proposal in the application to Parliament. He could also make available to Parliament the Environmental Statement and other supporting documents. Single debates would be held in each House on a motion moved by a Minister to approve the proposals. If both Houses pass the resolution the application would go forward for more detailed consideration at a public inquiry, which would focus primarily on local matters (PP 341-343). Application of this type of procedure to nuclear waste repositories would require primary legislation (see pp14-15 of Modernising Planning): this could be part of the Act which sets out the national nuclear waste management policy and gives the Commission its statutory powers.

6.36 At the public inquiry the environmental impact of the repository would be considered in detail. It is likely that objectors would argue against national policy and question the site selection process, as well as raising local issues. The Inspector should not rule out any arguments which are relevant. Nevertheless, the debate should be less extensive than at previous public inquiries on nuclear matters because the national policy will have been endorsed by Parliament, and the site selection process will have been established via consultation and carried out openly with Parliamentary involvement (Q 1236). The outcome of the public inquiry would be a recommendation from the Inspector that the repository should or should not go ahead at that site. In the latter case the Inspector might indicate which of the other short-listed sites appeared preferable or refer the matter back to the Company. The final decision would be made by the Secretary of State, based on the Inspector's report, and would be embodied in an order.

6.37 We believe that a process like that outlined above has the features necessary to balance national need with local concerns in an open and explicit way. The process would not give the local community a right of absolute veto but it would give them many opportunities to make their views known, and for those views to be taken into account. It would ensure that they are consulted at every stage, provided with all the relevant information and offered compensation for blight.

6.38 Table 3 summarises the actions which would be taken by Parliament, Government, the Commission, the Company and the regulators if the approach described above is followed, and gives very approximate timings. We believe that the approach would achieve the goal of emplacing wastes in repositories before modern surface stores have to be extensively refurbished or replaced (see Chapter 4), but all phases of consultation may take longer than we have indicated. It is important that the process is thorough and, because of its duration, that it is set in train by Government without delay.

Table 3 Possible Sequence of Actions by Parliament, Government, Nuclear Waste Management Commission, Radioactive Waste Disposal Company and Regulators

Year (approx)	Parliament	Government	Commission	Company	Regulators
1		Decides to develop comprehensive policy and issues Green Paper, indicating that it is minded to pursue phased geological disposal			
2		Sets up Commission without its statutory powers, to conduct consultations			
		Establishes complete inventory of long-lived wastes	Consults and recommends policy and site selection process		Input to consultation
	Debates White Paper	Formulates policy, issues White Paper, drafts Bill to establish policy, Commission, site selection process, and changes to planning law			

4	Debates, amends and passes Bill		Formulates research strategy	Set up by industry	
5	Receives Commission's first annual report	Input to long list of sites	Begins consultation and desk studies to establish long list of repository sites; begins research	Begins R&D, input to long list of sites	Establish relationship and dialogue with Company
6-7	Receives Commission's annual reports, reaffirms policy	Input to short listing of sites	Starts comparisons of sites on long list, and consultation and/or volunteering to derive short list of sites	Input to short listing of sites	Input to short listing of sites
8	Receives Commission's annual report containing short list of sites		Continues research, monitors work of Company	Begins investigation of short listed sites, consulting with local populations	Monitor work of Company
9-14	Receives Commission's annual reports, reaffirms policy		Continues research, monitors work of Company	Continues investigation of short listed sites, consulting with local populations and publishing results	Monitor work of Company, establish mechanisms to assess safety cases
15	Receives Commission's annual report		Monitors site comparison and selection, comments on draft Environmental Statement	Compares sites and selects preferred site, issues draft Environmental Statement	Start assessment of pre-construction safety cases
16	Receives Commission's annual report			Applies for order to allow repository development at preferred site	
17	Considers application for Order	Calls local Public Inquiry			Complete assessment of pre-construction safety cases
18-19	Receives Commission's annual reports		Gives evidence to Public Inquiry	Puts case at Public Inquiry	Give evidence to Public Inquiry
20	Receives Commission's annual report	Decides whether repository development should proceed, on basis			

		of Inspector's report			
21	Receives Commission's annual report		Monitors work of Company	Begins repository construction	Start assessment of pre-operational safety cases
22-23	Receives Commission's annual reports		Monitors work of Company	Constructs repository	
24			Monitors work of Company	Begins waste emplacement	Complete assessment of pre-operational safety cases

FUNDING ARRANGEMENTS

6.39 It has been suggested to us that the United Kingdom arrangements for funding nuclear waste management research, regulation and implementation could be made more transparent (e.g. Barker, 1998[53]). We also have concerns about continuity of funding over decades, and perhaps centuries, bearing in mind the possibility that the nuclear industry may cease to exist in its present form.

6.40 The principal new mechanism proposed to us is the setting up of a segregated fund, to which the whole of the nuclear industry would contribute, and which would be administered by some independent body (see, for example, the Environment Agency pp 122-123). This would seem similar to the funding arrangement in Sweden. It would help to allay concerns that financial provisions for nuclear waste management are inadequate (see, for example, p 220, Q 367).

6.41 We have sympathy with the proposal for a segregated fund. We recommend that the Nuclear Waste Management Commission be financed by such a fund derived from a levy on the whole nuclear industry (privately and publicly owned, civil and defence). We would also be in favour of financing other nuclear waste management activities in this way, particularly repository development, operation and closure. However, we are aware that such an arrangement would be unique to nuclear waste and may be difficult to accommodate within the present system of Government funding. We recommend that the Commission consults on funding arrangements and Government decides following this consultation, subject to Parliamentary approval. Funding arrangements would have to feature in the proposed Bill (6.21).

REGULATORY ROLES AND RESPONSIBILITIES

6.42 It is not part of the scope of this enquiry to comment in great detail on the roles and responsibilities of the organisations which regulate the nuclear industry. Nevertheless there are some issues which arose from the evidence presented to us which merit discussion. These concern the three principal civilian regulators, the Environment Agency (for England and Wales), the Scottish Environment Protection Agency (SEPA), and the Health & Safety Executive (HSE). They also concern the Ministry of Defence (MoD), which regulates those parts of its own sites which are not subject to the civilian regulatory regime.

6.43 In evidence to us the Environment Agency expressed concern that they have no legal powers to regulate the storage of radioactive waste on nuclear licensed sites (p 122). Their only powers over storage, and also over waste conditioning and packaging, are those deriving from a memorandum of understanding with HSE. A major problem with this arrangement is that until the Environment Agency receives a formal application for authorisation to dispose of stored waste, it cannot recover any costs of regulating the waste, nor can it require the owner of the waste (or the operator of the disposal facility for which the waste is destined) to provide it with information. This could lead to considerable difficulties if a deep repository were designated initially to be a storage, rather than a disposal, facility because the Agency could not regulate the repository or inspect the waste (Q 588).

6.44 To rectify this situation the Agency proposes that it be given a new statutory power over the storage of radioactive wastes on nuclear licensed sites, to co-exist with the HSE powers. Under the new power the Agency's approval would be required for arrangements to treat, package and store waste, and the Agency would inspect these arrangements and require improvements to be made if necessary. The power would enable the Agency to fulfil its responsibility to protect the environment during the long-term storage of wastes and to ensure that wastes are maintained in a suitable condition for ultimate disposal (PP 303-306).

6.45 Further advantages of the proposed new power would be to increase the information available to the public about waste storage arrangements, and to make the Agency involved fully at a much earlier stage in repository design and development (p 122). The Agency recognises that there are balances to be drawn between, on the one hand, health and safety, and on the other, environmental protection. It considers that the proposed new power would help to make the balancing process explicit and transparent, with public consultation (P 306). (The Nuclear Installations Act contains no provisions for public consultation, or for disclosure of information about wastes held on site. The only time when consultation and disclosure must take place is when an application is made, under the Radioactive Substances Act, to dispose of waste.)

6.46 Local interest groups (see, for example, p22) and local authorities (see, for example, p101) agree with the Environment Agency that the present situation is not satisfactory. The nuclear industry would also wish to see earlier formal involvement of the Environment Agency in repository development (see, for example, p36). HSE expressed the view that it is working arrangements that matter, rather than the statutory division of roles, and that the arrangements between itself and the Environment Agency (and its predecessors) have always been satisfactory (p 161, Q 655, Q 676, Q 692). HSE also pointed out that it is introducing a new system of reporting back to the public, via the local liaison committees at nuclear licensed sites, on regulatory activities, and that it is conscious of the possible implications of a Freedom of Information Act (Q 696).

6.47 These differences of view led us to ask the Environment Agency and HSE whether there would be merit in having only one regulator to cover all aspects of nuclear sites (QQ 588-598, QQ 675-693). Both organisations said that it is in the nature of the problem that there can be conflicts of priority between health and safety and environmental protection, and that this situation could not be changed by changing regulatory responsibilities. Dual regulation is already established in many other areas and is being extended, for example to sites that constitute a major accident hazard (P 304).

6.48 We conclude that it would not be worthwhile to make all the changes to primary legislation which would be required to give one organisation all the regulatory responsibility for nuclear sites. It would be contrary to other regulatory developments to do so and would not necessarily make for more constructive and open balancing of health, safety and environmental protection. We agree that the Environment Agency should be given the proposed new power it seeks over waste treatment and storage, because we feel that the advantages in terms of its formal involvement in the decision process and an increase in transparency outweigh any possible disadvantages of dual regulation with HSE.

6.49 A further issue is the regulatory position at MoD sites. Those MoD sites which are operated by private contractors are subject to the full civilian regulatory regime. Other MoD sites are visited by inspectors from HSE and the environment agencies but are legally regulated by MoD themselves. In some instances there are differences from one part of a site to another. For example, most of the Devonport Royal Dockyard is a nuclear licensed site, operated by DML, but all testing and running of the reactors in nuclear submarines is done on parts of the site operated by MoD, under MoD's own regulatory regime (Q 338). There is general agreement that it is desirable to bring all MoD sites under the full civilian regulatory regime as soon as practicable, but progress is at present very slow (QQ 349-350). We wish to see ways found to speed it up.

INTERNATIONAL DEVELOPMENTS

6.50 From our discussions with staff of international agencies (the European Commission, NEA and IAEA) we concluded that these agencies work well as fora for discussions amongst nuclear industries and their regulators, but poorly as catalysts for action (see Chapter 3). It is particularly disappointing that the agencies have not succeeded in promoting regional solutions to nuclear waste management for groups of countries which have relatively small amounts of waste to deal with and for countries which lack the infrastructure or resources to establish their own repositories.

6.51 Our view is that it is entirely appropriate for countries which have substantial waste legacies to develop their own deep repositories for their own wastes. In some of these countries, including the United Kingdom, more than one repository may be required and it would not be sensible to import waste from elsewhere for reasons of public acceptability. For countries with less waste the best policy is to pool resources.

6.52 We recognise that it is likely to be ineffectual for the United Kingdom to promote or support regional repository initiatives until we have made more progress in solving our own nuclear waste problem. We recommend that when our policy consultation is complete, and if the chosen policy is phased geological disposal, this country should take a lead in international discussions on regional repositories and offer help to those countries that need to develop them, but lack the resources. Help is particularly needed in eastern European countries.

CONCLUSIONS AND RECOMMENDATIONS ON POLICY AND ORGANISATIONS

6.53 We recommend that the Government should develop without delay a fully comprehensive policy for the long-term management of all nuclear waste. The policy should have explicit endorsement by Parliament, as well as a large measure of public acceptance.

6.54 To achieve public acceptance it is essential that the policy is the subject of wide-ranging consultation. We suggest that, having considered our report, the Government issues a Green Paper which states the problem, the possible solutions and the policy that the Government is minded to put to Parliament, and which seeks views on the principal means for implementation of that policy, including, for deep repositories, the site selection process. The consultation on the Green Paper should involve as many sections of the public as is feasible. At the end of it the Government should report the results to Parliament; this could be done via a White Paper that contains a full statement of the proposed policy. The development process should lead to a parliamentary Bill to establish the policy and the institutional framework for implementing it. It is essential that the policy is endorsed by Parliament at regular intervals during its implementation.

6.55 We recommend that a new organisation be set up to oversee the implementation of policy. This should be a "Nuclear Waste Management Commission", which is outside day-to-day government and which has authority and permanence. Members of the Commission should be drawn from a wide range of backgrounds and it should have scientific, technical and administrative staff. The workings of the Commission should be as open as possible, with a presumption that everything it produces will be published. There would be advantages in setting up the Commission initially in a non-statutory way and giving it the task of consultation on a comprehensive policy. The Bill which establishes the policy should give the Commission its powers of oversight.

6.56 Our view is that the United Kingdom should embark on a phased approach to geological disposal, in which surface storage leads to emplacement in one or more deep repositories, initially in a monitored and retrievable way. The Commission should carry out the first stage of a repository site selection process, consulting as necessary, perform research and make arrangements for research to be carried out, and provide information to whoever needs it.

6.57 Another new organisation should be set up with the remit to design, construct, operate and eventually close the repository (or repositories), conducting R&D as necessary. This "Radioactive Waste Disposal Company" should be a nuclear industry organisation (including the Ministry of Defence) which would need approval from the Commission for its work programme. There should be a presumption that the work of the Company will be available for public scrutiny.

6.58 For the present, Nirex should be maintained but when the Commission and the Company are established its roles should be subsumed by them. When the Commission is set up RWMAC should be disbanded.

6.59 The Commission should be responsible for co-ordinating all United Kingdom research on the long-term management of nuclear waste. It should take over this role during the consultation period and ensure that records of past research findings are preserved.

6.60 The process of selecting a repository site (or sites, if more than one repository is needed) should be open and transparent, and should involve Parliament and Government. The Commission should derive a long list of potential sites and, from this, a short list. It should then oversee the Company's selection of the preferred site(s). The Company's choice of site(s) should be debated in Parliament and examined at public inquiry. The final decision should be made by the Secretary of State.

6.61 The Commission should be financed by means of a segregated fund, derived from a levy on the whole nuclear industry (civil and defence). The Commission should consult those concerned about the desirability and practicability of funding repository development, operation and closure in a similar way, and make recommendations to Government.

6.62 When the Commission is set up some changes should be made to regulatory arrangements. The Environment Agency should be given a new statutory power over the storage of wastes on nuclear licensed sites. Efforts to bring all Ministry of Defence sites under the full civilian regulatory regime should be increased substantially and the Government should bring forward a timetable for achieving this objective. Further changes to regulatory arrangements might be needed as the Commission's work proceeds.

6.63 We recommend that when policy consultation is complete, and if the chosen policy is geological disposal, this country should take a lead in international discussions on regional repositories and offer help to those countries that need, but lack the resources, to develop them. Help is particularly needed in eastern European countries.

6.64 We strongly recommend that the Government starts work promptly and proceeds in a steady and measured way without interruption. The programme for repository development is a long one and cannot be rushed. Delay in starting the programme will increase the likelihood that extensive refurbishment or replacement of surface stores will be required.

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52 *Review of Radioactive Waste Management Policy, Final Conclusions*, Cm 2919, 1995. Back

53 Barker, Fred, *A Framework for Policy Review*, Paper presented at the Nuclear Free Local Authorities Conference on the Future of UK Radioactive Waste Policy, October 1997. Proceedings published by Thomas Telfords, 1998. Back

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PART C: OTHER WASTE MANAGEMENT ISSUES

CHAPTER 7: REPROCESSING, PLUTONIUM AND MOX

BACKGROUND

7.1 The United Kingdom faces complex challenges in nuclear waste management because of the variety and volume of wastes that must be dealt with. These wastes have resulted from the active role that the United Kingdom has played (and continues to play) in both civil and military developments since the Second World War. The United Kingdom has operated numerous different commercial and research reactor types (including submarine reactors), has had an active fuel reprocessing programme for military and commercial purposes since the 1950s, is a world leader in nuclear materials research and the application of nuclear materials for medical purposes, and operates facilities for fuel fabrication. The various programmes to clean up wastes from previous activities also generate their own waste, albeit in more manageable forms. Each operation often generates its own waste stream which may require a unique management solution because of the physical nature of the waste, or its chemistry, or its activity. The waste management task for the United Kingdom is thus comparable to that of the US, France, or the former Soviet Union, rather than to nations such as Sweden, Canada, the Netherlands and others which have only operated a limited number of different reactor types and have no nuclear weapons programme.

7.2 In this chapter we look at some of the issues for the United Kingdom which feed into the debate on longer-term solutions to nuclear waste. These include plutonium and its uses and the reprocessing of spent fuel. A description of the issues is given under each heading and this is followed by a review of what our witnesses told us. Our opinions are summarised at the end of the chapter.

REPROCESSING

7.3 Whether a country reprocesses spent fuel or not is a key factor in determining what types and volumes of waste have to be managed. This, in turn, may have a bearing on the long-term management strategy that can be used. Compared to a "once-through" fuel cycle, reprocessing reduces the volume of HLW, but increases the volume of ILW; this could have implications for the volumes of storage or repository space (or both) that will be required. Over the whole fuel cycle reprocessing can reduce the volume of LLW because if uranium and plutonium are recycled less uranium ore needs to be mined. This off-sets the small additional radioactive discharges to the air and sea at the reprocessing plant. The following table shows the volumes of LLW, ILW and HLW arising from 1 GW(e) year power generation for a fuel cycle with reprocessing and complete recycling of uranium and plutonium, and a once-through cycle[54]. If the uranium and plutonium produced by reprocessing are not recycled the situation is very different because of the large repository volume that is likely to be required to accommodate these fissile materials (see para 7.42).

Table 4 Waste arisings

Waste type	Waste volume (cubic metres)	
	Reprocessing	Once-through
LLW	15,152	20,060
ILW	36	11

HLW	5	40

7.4 Reprocessing involves the chemical and physical separation of uranium and plutonium from spent nuclear fuel. The fuel rods are first removed from their support structure and are chopped into sections. These sections are then dissolved in nitric acid in order to separate the fuel from its cladding. The resulting liquor undergoes chemical processing (e.g. using ion-exchange and organic solvents) and physical techniques (e.g. filtering and centrifuging) to separate the plutonium and uranium, that can be re-used, from various waste streams containing the fission products and fuel cladding.

7.5 The initial impetus behind reprocessing was to supply plutonium for research and the manufacture of nuclear weapons. More recently, reprocessing has been linked with the more positive image of recycling (e.g. in advertisements on British television by BNFL) to show how nuclear power can be a sustainable alternative to fossil fuels. There is a variety of reasons for reprocessing spent nuclear fuel:

· To produce plutonium (e.g. for weapons, fast reactors or mixed oxide fuel, MOX).

· As a waste management strategy for dealing with otherwise unstable fuel or fuel assemblies (e.g. for dealing with Magnox fuel).

· To reduce the environmental impact on uranium mining areas, by reducing uranium demand.

· To recover uranium for use in the manufacture of new fuel (which conserves supplies of uranium, may give a degree of fuel supply security, may be cheaper if the price of mined uranium is high, and can save on fuel enrichment[55]).

· To maintain a technological and commercial advantage over competitor nations.

· To generate income, much of which could come from overseas customers.

· To create employment.

7.6 The United Kingdom currently has three reprocessing plants: two major facilities at Sellafield for reprocessing uranium oxide fuels and Magnox fuel, and a minor facility at Dounreay for fuels containing a high proportion of plutonium or highly enriched uranium (see Box 3). The United Kingdom reprocesses spent fuel from its Magnox reactors, advanced gas-cooled reactors (AGRs) and some research reactors. As yet it has not reprocessed any spent fuel from submarine reactors or from the Sizewell B pressurised water reactor (PWR). BNFL Sellafield is reprocessing substantial quantities of fuel from overseas customers, particularly oxide fuels from PWRs and other light water reactors in countries such as Japan.

7.7 Because of the reprocessing programme, spent reactor fuel in the United Kingdom is not considered to be a waste. A similar policy in favour of reprocessing has also been adopted by other countries including Japan, France, Belgium and India. A number of eastern European countries also favoured reprocessing in the past, although most of their contracts were with the former Soviet Union and it is now not clear if or when reprocessing will be carried out. The two principal countries engaged in commercial reprocessing are now the United Kingdom and France.

7.8 Some countries (including Canada, Sweden, Finland, and Spain) have decided not to reprocess their spent fuel; the US does not reprocess the spent fuel from its civil reactor programme. With no re-use envisaged, the spent fuel is declared as waste. As it is not usually proposed to remove the spent fuel from its support structures, the whole of the fuel assembly becomes what in the United Kingdom would be termed high level waste (HLW).

7.9 For those countries which do reprocess, and regard plutonium as an asset, one advantage is the reduced volume of HLW that must be dealt with (see paragraph 7.3). Disadvantage are the intermediate level waste generated by reprocessing, the discharges of radioactive effluents to air and sea, and the effort that must be devoted to the storage of plutonium.

Box 3: Reprocessing in the United Kingdom

Magnox

Magnox reactors use un-enriched uranium metal fuel rods enclosed in a cladding of magnesium alloy. This fuel is reprocessed in the B205 plant at Sellafield. Reprocessing of Magnox fuel started at Sellafield in 1952 and more than 40,000 tonnes have been reprocessed since then. Reprocessing is likely to continue for at least another 10 years as the remaining Magnox power stations are not expected to close before 2007. One reason why the spent fuel is reprocessed is because of the technical problems which result from contact with water: the fuel cladding corrodes, and the fuel reacts with water to produce uranium hydride (which can ignite spontaneously in air). Contact with water occurs because the spent fuel is cooled under water after being removed from the reactor. Contact with water would also be likely in a repository. This suggests that reprocessing of Magnox spent fuel will have to continue until all of the fuel has been treated.

THORP

The Thermal Oxide Reprocessing Plant (THORP) treats uranium oxide fuel from advanced gas-cooled reactors (AGRs) and water-cooled reactors. The plant became operational in 1994 and it completed the final part of the regulatory approval process for commissioning in August 1997. After a steady build-up of activities, the aim is to achieve and maintain a through-put rate (the rate at which fuel is reprocessed) of 900 tonnes per year. It is expected that 7,000 tonnes of fuel will be reprocessed in the first ten years of operation. THORP cost £1.85 billion to build and is designed to have a 25 year lifespan (PP 286, 292).

The fuel for AGRs and water-cooled reactors is ceramic uranium oxide enriched with between 1.5 and 4 per cent fissionable uranium-235. AGR fuel rods are clad with stainless steel. The fuel for water-cooled reactors is clad in a zirconium alloy which, like the fuel itself, is very stable. Spent AGR fuel is more of a problem because of slow corrosion in the fuel rod cladding after exposure to water. It is technically difficult to completely dry the AGR fuel after immersion in water because the rods have graphite sleeves which retain moisture; it is also difficult to remove these sleeves without damaging the fuel itself (P 287, POST Report*, Sumerling 1997**).

Dounreay reprocessing

The UKAEA site at Dounreay includes a small commercial reprocessing facility. This deals with fuels from research reactors including the Materials Testing Reactor (MTR) and Prototype Fast Reactor at Dounreay, and MTRs owned by overseas customers. In March 1998, approximately 5 kg of highly enriched uranium and 9 kg of low enriched uranium were delivered to the site from a research reactor in Georgia (a former Soviet Republic). The transfer was made because of concerns over its safety in the light of political instability in the region. The material will be reprocessed and the Government announced that some of it could be used for medical purposes. Because of the circumstances of the transfer, the small amount of waste from reprocessing will not be returned to Georgia.

It was announced on 5 June 1998 that commercial reprocessing at the Dounreay site would cease once existing contracts had been completed. John Battle MP (then Minister for Science, Energy and Industry) told the House of Commons that the decision was being taken because there was no economic case for supporting commercial reprocessing at Dounreay in the long term (Commons Hansard, 5 June 1998, Col 385).

*Radioactive Waste-Where Next?, Parliamentary Office of Science and Technology, November 1997.

** Options for Disposal of Nuclear Fuel Waste: Alternatives Evaluated Abroad or Internationally, TJ Sumerling, Safety Assessment Management Ltd., Report for SKB (Sweden), June 1997.

7.10

7.11 The discharges to the sea from Sellafield reached their peak in the mid-1970s as a result of corrosion in Magnox fuel assemblies which had been stored underwater for longer than desirable[56]. Since then, the introduction of new treatment plants has reduced the activity of discharges to sea by about a factor of one hundred[57]. The radiation doses from these discharges to the most exposed members of the public have decreased from a peak of about twice the national UK average natural background dose in the mid 1970s to about one tenth of the average natural background dose now[58]. At the 1998 Ministerial Meeting of the OSPAR Convention[59] in Portugal (22-23 July), the Government agreed to make further reductions in radioactive discharges to the sea by 2020.

7.12 Discharges of the fission product technetium-99 (a long half-life beta-emitter) have increased recently as a backlog at the Magnox reprocessing plant has been dealt with. BNFL are looking at technology for reducing these discharges, while technetium-99 from THORP is already stored with other HLW and will be vitrified (Commons Hansard, 28 July 1998, Col. 125).

Views of witnesses on reprocessing

7.13 Many witnesses, including the National Steering Committee for Local Authorities (p 220), Friends of the Earth (QQ 507, 526-529, pp 131-132, PP 319-321), Greenpeace (Q 417), Cumbrians Opposed to a Radioactive Environment (CORE, pp 106-107), the Consortium of Opposing Local Authorities (COLA, p 92), the Nuclear Control Institute (pp 231-232) and CND (p 55) said that reprocessing of spent fuel should be stopped. They argued that the products of reprocessing (i.e. separated plutonium and uranium) are not needed, and that reprocessing only compounds the existing problems because it generates more waste and environmental pollution. They also said that it creates further health and safety risks, is costly, and increases the possibility of nuclear proliferation. Greenpeace said, "The discharges from reprocessing to the air and to the sea are causing substantial problems...This is not a marginal problem. It is a major international problem and we should end it" (Q 418).

7.14 The Irish Government (pp 187-189) told us that it remained firmly opposed to any expansion of the nuclear industry and described the facilities at Sellafield as "part of an inexorable and increasing threat to Ireland's public health and environment" (p 187). They said that nuclear waste management policy should take more account of the effects on health and the environment beyond national borders, the precautionary principle should be observed at all times, and the polluters should pay for the burden placed on society and economy in Ireland (p 188).

7.15 A report by SERA (the Socialist Environment and Resources Association)[60] described reprocessing as a "powerful sacred cow within the British nuclear industry". The report stated that reprocessing creates over two thirds of Britain's annual arisings of ILW, large volumes of LLW and about 9 tonnes of plutonium a year (the latter requiring storage costing £1 million per tonne per year). SERA concluded: "The end result is we are shackled with high electricity bills and subsidies to support a process which has no economic or technical justification, which saddles us with more and more nuclear waste, which causes radioactive pollution throughout Europe, and which creates highly dangerous plutonium. It's time we stopped this nonsense." SERA's alternative to reprocessing would be dry storage of the spent fuel.

7.16 In general, the views of the nuclear industry are favourable towards reprocessing. British Nuclear Fuels told us that only about ten per cent of the volume of ILW expected to be accumulated by about 2050 would be avoided if nuclear power generation and fuel reprocessing were to stop immediately. Waste from past activities and decommissioning could not be avoided (pp 34-35). BNFL also argued that the product of reprocessing was useful: they told us that forty per cent of the fuel used in the AGRs had come from reprocessed Magnox fuel (Q 127).

7.17 When evaluating the benefits and impacts of reprocessing, BNFL and the Environment Agency said that the whole fuel cycle, from mining uranium to eventual disposal, should be considered. The Environment Agency added "one would be quite justified in considering the (impact of the) totality of a nuclear fuel cycle on the environment, not just your own environment but other people's environment" (Q 560). BNFL estimated that reprocessing resulted in only 75 percent of the LLW, and 80 per cent of the ILW and HLW, that would be generated if virgin materials were used and if spent fuel were disposed of directly (Q 127). Hence, BNFL regarded reprocessing as "a best environmental option" (Q 135).

7.18 The DETR told us that it was "not aware of any definitive study which clearly identifies either the reprocessing or direct disposal route for spent fuel management as being preferable from an environmental point of view". Those studies which had been undertaken depended on making a plethora of assumptions and were complicated by there being no single measure for environmental impact (PP 298-300). For AGR fuel, RWMAC compared the options of early reprocessing, delayed reprocessing and not reprocessing at all and concluded that "all three options have impacts which are small and comparable within the bounds of the uncertainties in the estimates" (11th Annual Report, 1990).

7.19 BNFL said that reprocessing gave various benefits for the natural environment of the United Kingdom (P 287, PP 292-293):

· it allowed plutonium to be burnt in reactors (thus reducing the total inventory of plutonium in the world when compared to using fresh uranium fuel);

· it reduced the volume of highly active waste that had to be disposed of;

· it conditioned wastes in forms that are safe to dispose of or store;

· through overseas contract income, reprocessing had substantially reduced the costs of treating the United Kingdom's historic and future nuclear waste.

7.20 BNFL also told us that it would be technically possible to construct a reprocessing plant which was designed for waste management purposes, rather than for the recovery of fuel quality uranium and plutonium. They said that a variety of technologies had already been researched, but further development would be needed if this were to be pursued. Such a plant would only require a one-stage chemical separation process and, if this was the desired objective, a new facility might make better economic and safety sense than making modifications to THORP (P 287).

7.21 The UKAEA agreed that reprocessing was still a safe and credible option for the United Kingdom and that it should continue to be used to convert Magnox fuel into a more stable form for the long term. The UKAEA also said: "in terms of modern power stations then clearly there are the equally credible options of either continuing to reprocess or to cease reprocessing and store the irradiated fuel" (UKAEA, Q 240).

7.22 Long-term dry storage of AGR fuel had been considered by Scottish Nuclear (now a subsidiary of the privatised British Energy) as an alternative waste management option to reprocessing. The company had started planning a storage site adjacent to its Torness power station in Scotland, but, for economic reasons, this was not pursued and Scottish Nuclear signed a contract with BNFL in 1995 for the management of all of its spent AGR fuel (Q 782). Nuclear Electric (the British Energy subsidiary in England) also made a similar deal. The combined contract is worth around £1.8 billion and will cover the reprocessing of approximately 4,700 tonnes of uranium fuel, ie all the spent fuel produced by AGRs over their expected lifetime (P 287, P 293). British Energy said that it was now for BNFL to decide whether to store or reprocess this fuel. The company was aware of the various arguments against reprocessing voiced by environmentalists and interest groups, but they had no reason to disagree with the original inquiry findings which had said that THORP was environmentally sound (QQ 777-784).

7.23 The economic arguments for continuing with reprocessing, and to continue operation of the THORP plant in particular, were presented by BNFL and the National Campaign for the Nuclear Industry. The economic base of west Cumbria is strongly linked to the fortunes of BNFL: it is the largest employer in the area and many of these jobs are linked to reprocessing activities (NCNI, pp 212-213). BNFL said that it thought there was a healthy future for THORP: the company said it has a 16 year order-book for THORP worth over £12 billion; there are good prospects that a further £5 billion of orders can be secured; and a nuclear renaissance was expected in the next century, led by countries such as China (Q 127, P 292). A profit of at least £500 million (in 1992 money) was expected in the first ten years of operation after accounting for all capital and decommissioning costs (P 286). BNFL concluded that THORP is justified on the basis of the economic benefits and lack of serious environmental disbenefits (QQ 130-135)[61].

7.24 An alternative view on the economics of THORP was published during the course of our enquiry: Future THORP Available Cash Flows, M.J. Sadnicki for the National Steering Committee of Nuclear Free Local Authorities, April 1998. In this paper it is calculated that THORP could only make a profit if several parameters such as the fuel through-put rate and contract prices were at the upper end of their possible range.

MIXED OXIDE FUEL

7.25 Mixed oxide fuel (MOX) is the principal means by which plutonium, separated from spent fuel during reprocessing, could be used for power generation. An alternative option, use in fast breeder reactors, is discussed briefly in the next section. MOX is important in waste management terms because it allows the re-use of some of the material in spent fuel that would otherwise be classified as waste. Using MOX could reduce the need for 'virgin' uranium in reactor fuel, and thus could have an important impact on those areas where uranium is mined. MOX could also have advantages for decreasing the risk of nuclear proliferation: locking up plutonium in MOX would make it less accessible for weapons production, although still accessible by chemical means to the most determined.

7.26 Typically, MOX contains 5-8 per cent of plutonium in oxide form mixed with uranium oxides. The isotope plutonium-239 is fissile and, like uranium-235 in standard reactor fuel, provides the driving force for the fission reactions needed to generate heat. A number of countries are operating reactors using MOX, although the United Kingdom has not yet done so (see Box 4). No reactors have yet been built with MOX specifically in mind from the outset, but it has been used successfully in some water-cooled reactors. Where MOX has been used it has been as part of a mixed fuel load with normal reactor fuel, with up to one third of the load being MOX. Extra safety procedures, and in some cases extra radiation shielding, are required when MOX is used because spent MOX fuel is more radioactive and more radiologically hazardous than spent uranium metal or spent uranium oxide fuel due to the presence of greater concentrations of actinides and fission products.

7.27 MOX can be used in a "once-through" fuel cycle or in a cycle with reprocessing. The number of times that MOX fuel can be reprocessed is limited by the build-up of the heavier actinide elements in the fuel and the maximum is three or four. Thus in both the once-through and reprocessing cycles spent MOX fuel arises as waste; in the reprocessing case there is also liquid HLW for solidification and disposal.

7.28 In 1996 the world-wide MOX fabrication capacity was estimated by the nuclear industry to be around 124 tonnes per year. Estimates for expected capacity in the year 2000 range from 439 tonnes per year (by industry) to 229 tonnes per year (by the World Information Service on Energy).[62]

Box 4: Some national policies for MOX	
Belgium	Two out of seven reactors are loaded with 20 per cent MOX. There is a commercial scale MOX fabrication plant at Dessel.
France	16 out of 56 reactors are currently licensed to use MOX, and 12 of these have been loaded

	with 30 per cent MOX. France operates most of the world's capacity for MOX fabrication (including 'MELOX', the world's largest MOX plant). A further plant is planned.
Germany	12 out of 20 reactors are licensed for MOX; seven of these are using this fuel. In January 1999 the coalition parties announced they would ban reprocessing fuel from January 2000 and would amend the existing law to allow a phasing out of nuclear power.
Japan	Two out of 53 reactors have been partly fuelled with MOX for demonstration purposes. It is expected that MOX will be used in three or four reactors by the year 2000, and ten reactors by year 2010. One small MOX fabrication plant is in operation and a larger plant planned.
Switzerland	It is expected that two out of Switzerland's five reactors will be partly loaded with MOX by the end of the century.
U.K.	The UK has no present plans to use MOX. The Sellafield MOX fabrication plant is constructed but not yet licensed.
U.S.	Investigating the possibility of using MOX in commercial reactors as a means of disposing of plutonium from their nuclear weapons programme.
Others	The Netherlands, Sweden, and Canada have no plans to use MOX in their reactors.
Sources: International MOX Assessment, 1997; Foreign Press Centre, Japan, 20 February 1998.	

Views of witnesses on MOX

7.29 BNFL is just completing a new MOX fabrication plant, the Sellafield MOX Plant (SMP), which is expected to have a production capacity of 120 tonnes of MOX per year. The Environment Agency has decided that its discharges should be authorised (ie that the plant can start operating) but the authorisation is awaiting ministerial decision. The Environment Agency told us that it had conducted a two month consultation exercise and had evaluated the technical case presented to it by BNFL. It had also contracted the PA Consulting Group to examine the economic case for the plant (QQ 577-587). The public version of the economics report concluded that the plant will produce significant levels of operational profit: "very unlikely to be less than £100 million, exceeds £300 million in many options, and on average amounts to £230 million"[63]. Friends of the Earth said that "the economic justification presented for this plant [the SMP] is based upon information withheld from the public domain and which does not consider alternatives" (p 320).

7.30 BNFL told us that Japan would like all of its plutonium from reprocessing returned in the form of MOX, and Germany was heading the same way (Q 139)[64]. MOX burnt in civil reactors might be a way of dealing with plutonium stocks in the former Soviet Union (Q 140), although it would take several decades to do so.

7.31 In the United Kingdom, British Energy said that it might consider using MOX at Sizewell B although a number of issues needed to be addressed. These included steps to minimise radiation dose from the fuel assemblies, appropriate security arrangements during fuel transport and handling, and addressing all of the regulatory matters involved in licensing (P 277). The short-term cost of using MOX at Sizewell would be higher (because MOX fabrication is expensive), but there would be long-term savings from reducing the amount of plutonium which would eventually require disposal (QQ 809-810). The Cumbria and North Lancashire Peace Groups disagreed, arguing that spent MOX posed greater problems for ultimate management because it contained a higher proportion of long-lived actinide elements (p 105)[65]. British Energy concluded that "the economics of MOX use in Sizewell B are not currently competitive with uranium fuel" (P 277). Utilisation of MOX in AGRs had also been reviewed but was not considered to be practicable (P 277).

7.32 Because of international agreements on nuclear proliferation and the transfer of plutonium, MOX that is intended for sale overseas can only be produced using plutonium supplied by the country wishing to use that fuel. BNFL told us that there would be a significant world market for nuclear power in the next century even if only the most conservative estimates of energy demand were to be met: "under these circumstances the plutonium would represent a valuable potential source of energy" and "the potential market [for MOX] exceeds the amount of plutonium that will be available" (P 289). In contrast, the IAEA estimates that under free market conditions for MOX the world stock of separated civil plutonium could be reduced from the current level of 170 tonnes to about 50 tonnes by 2013[66]. Without a free market IAEA expects the world-wide rate of production of plutonium and its rate of use as MOX to come into balance in a few years' time; until then stocks will continue to increase.

7.33 BNFL also said the environmental advantages of using MOX make it important when considering carbon dioxide and other emissions: one tonne of plutonium when recycled as MOX contains the same amount of energy as 2 million tonnes of coal (P 293). The BNFL web site states: "The Sellafield MOX Plant is a recycling plant. Using product from reprocessing, it will have the capability, during its 20 years lifetime, to produce around 2,000 tonnes of nuclear fuel creating the equivalent of 640 terawatt hours of electricity—enough to provide electricity to the whole of the United Kingdom for more than two years".

7.34 On the other hand the Royal Society report[67] noted that using MOX does not necessarily reduce the amount of plutonium in existence. New plutonium will be generated from uranium-238 in the fuel as it captures neutrons released during the fission of plutonium. The balance between consumption and creation would depend on the isotopic content of the fuel, the fraction of the fuel load that is MOX, and the fuel burn-up rate. Thus MOX fuel itself could be reprocessed to recover plutonium for future use (although the build up of higher mass actinide elements restricts the number of times that MOX can be reprocessed, see paragraph 7.26). The report also stated: "Reprocessing of spent fuel solely to produce plutonium for recycling as MOX is not economic. But given that reprocessing has been carried out and the plutonium is available, then the extra cost of fabricating MOX fuel (as compared with enriched uranium fuel) might be justified in view of the savings in uranium and enrichment costs"[68].

PLUTONIUM STOCKS

7.35 As discussed above, plutonium is one of the products of reprocessing spent nuclear fuel. In the United Kingdom, plutonium is separated out from the recovered uranium during reprocessing, it is converted into insoluble plutonium dioxide, and it is kept in secure storage at Sellafield.

7.36 The Royal Society estimated that the United Kingdom now has 53.5 tonnes of separated civil plutonium in stock. This includes plutonium held by BNFL for its overseas reprocessing customers (thought to be less than 5.5 tonnes). Most of the current stocks have been generated from the reprocessing of Magnox fuel. By 2010 the stock will have risen to over 100 tonnes and, at that time, the United Kingdom will hold about two thirds of the world's separated civil plutonium. The overall global inventory of plutonium by 2010 will be over 2,000 tonnes, but almost all of this will be locked up in spent fuel or MOX and thus it will not be readily accessible[69].

7.37 In terms of waste management, plutonium is a special case because of the nuclear proliferation risk that it poses. Also, if it were to be disposed of or stored indefinitely, there is a remote risk of a non-explosive critical nuclear reaction occurring should enough plutonium come together in the right physical configuration. Plutonium also presents a relatively high radiological hazard because of the damage it can cause (through alpha-particle radiation) if it is inhaled into the human body.

7.38 The United Kingdom does not categorise plutonium as a waste, but it is given a zero value in BNFL's balance sheet. The potential for using plutonium in MOX has already been discussed and there could be an even greater potential for future use in fast breeder reactors. Fast reactors use a fuel rich in plutonium (20-35 per cent)[70] plus non-fissile uranium-238. In theory, fast reactors are around sixty times more efficient than other reactors and, in the 1970s they were expected to be a major source of power for the future[71]. However, there have been a number of technical and economic problems with fast reactors which has made their future uncertain.

7.39 The United Kingdom shut down its prototype fast reactor at Dounreay in 1994. Development of fast reactors in Japan has hit problems following a sodium leak at the Monju prototype fast reactor in December 1995. In 1998 the new French Prime Minister, Lionel Jospin, confirmed that France was permanently shutting down its Superphenix fast reactor for "economic reasons"[72].

Views of witnesses on plutonium

7.40 BNFL told us that storage of separated plutonium for possible future use was not a problem. They spend £10 million annually on security and safeguards associated with plutonium on the Sellafield site and that, "guarding one tonne of plutonium is as costly as guarding 50 tonnes". Over 35 per cent of these costs were currently being met by overseas reprocessing customers. BNFL said, "The issue surrounding plutonium is not the quantity stored, but the international safeguards and security regime to which the stored material is subjected. The better funded the regime then the better the safeguards" (PP 292-293).

7.41 The UKAEA told us that it did not see fast reactors being required for the next 50 to 100 years (Q 291). This, and the fact that MOX is not yet used in the United Kingdom, means that currently there is no significant demand being placed on our plutonium stocks; indeed stocks are increasing. It has been argued that plutonium might therefore be more of a liability than an asset. Some witnesses, including Friends of the Earth, consider that plutonium is a waste product from reprocessing (P 319). The Science Policy Research Unit at the University of Sussex estimated that managing our plutonium stocks as HLW would cost the United Kingdom around £2.3 billion (in 1997 money) by the year 2105[73].

7.42 Again, if plutonium is regarded as a waste, and if disposal is advocated, then some witnesses suggested that this could cause problems. Sir John Knill and others told us that natural processes could re-concentrate plutonium, so the best option would be to distribute it as small particles within other wastes and then distribute these wastes throughout a repository. The amount of plutonium in normal wastes was not thought to present too much of a problem, but the safe disposal of separated stocks would be another matter entirely. Sir John thought that some special method of disposing of plutonium may be required in the future (Q 1033).

7.43 The DETR is also considering what the implications would be if plutonium is classified as a waste in the future. They have commissioned QuantiSci to conduct a study into the disposal of HLW, spent fuel and other materials, including plutonium and uranium from reprocessing. A concern that is being investigated is whether more than one deep repository would be required in order to cope with the potential waste volumes (Q 161). This could have significant implications for the United Kingdom's nuclear waste management strategy. The interim report from QuantiSci[74] states that if these materials are classified as wastes and are designated for disposal in a repository, then "there would be a substantial impact on the required repository design and thus size of the supporting R&D programme, particularly if safeguards and criticality issues become more important, due to the inclusion of more plutonium". QuantiSci added that, "Whilst it would be possible to include additional wastes late in a deep repository development programme, this could result in sub-optimal decisions being taken, so the types of waste to be included in the programme should be specified as early as possible".

7.44 In 1998 the United Kingdom became the first nuclear weapons state to declare the size of its defence-related stocks of fissile materials. Our stock of defence-related plutonium was said to be 7.6 tonnes. In the Strategic Defence Review, when these figures were released, it was announced that there was a surplus of 4.4 tonnes of plutonium including 0.3 tonnes of weapons-grade material[75].

7.45 In its report on The Management of Separated Plutonium, the Royal Society considered that there was an international consensus against having a large stock of separated civil plutonium because this posed a significant environmental and security risk, and left "an open-ended legacy for future generations". The Royal Society concluded that the Government should review its strategy and options for stabilising and then reducing the stocks of plutonium, subject the options to independent review, and maintain R&D capabilities so that competing options could be evaluated. The various options discussed included: use of MOX in current reactors, building new reactors specifically designed for MOX, using plutonium from United Kingdom stocks in MOX sent abroad, disposal of plutonium in a repository, and use as fuel in some advanced (fast) reactor whose fuel cycle eliminates plutonium.

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54 From Butler, Gregg, *Nuclear fuel: recycle or dispose? How? Where? When?* Interdisciplinary Science Reviews Vol.23 No.3 p292-297 (1998). Back

55 Where reactor fuel enriched with uranium-235 is used, the spent fuel is still enriched relative to naturally occurring uranium. Thus, less re-enrichment is required to produce new fuel from this material. Back

56 RWMAC, 11th Annual Report, 1990. Back

57 BNFL Annual Report and Accounts, 1998. Back

58 MAFF and SEPA, *Radioactivity in Food and the Environment in 1997*, report RIFE-3, 1998. Back

59 The Convention on the Protection of the Environment of the North-East Atlantic. Back

60 *A Nuclear Waste: how ending reprocessing can benefit public health, protect the environment and save up to £6 billion*. Report by SERA, Labour Environment Campaign, January 1998. Back

61 Evidence given in February 1998. Back

62 The IMA Report: *Comprehensive social impact assessment of MOX use in light water reactors.* Final report of the International MOX Assessment, for the Citizens' Nuclear Information Centre, Japan, November 1997. Back

63 *Assessment of BNFL's Economic Case for the Sellafield MOX Plant*, PA Consulting Group for the Environment Agency, December 1997. Back

64 Since taking that evidence, there has been a change of policy in Germany. Back

65 Spent MOX also has a higher thermal load than standard uranium spent fuel and thus requires a longer period of cooling before it can be reprocessed or put in storage. In addition, the beta and gamma activity is up to six times higher and the plutonium content five times higher than spent uranium fuel (*Nuclear Fuel*, Volume 23, No. 4, February 1998). Back

66 IAEA Bulletin 40/1/98. Back

67 *The Management of Separated Plutonium*, The Royal Society, February 1998. Back

68 The Royal Society, *ibid.* *Back*

69 The Royal Society, *ibid*. Back

70 Alternative fuel cycles using thorium and uranium could also be used. Back

71 Royal Commission on Environmental Pollution 6th Report, 1976, *Nuclear Power and the Environment.* *Back*

72 General Policy Statement given by Lionel Jospin, 19 June 1998. Back

73 *Managing United Kingdom Nuclear Liabilities*, SPRU, October 1997. Back

74 QuantiSci, *High-Level Waste and Spent Fuel Disposal Research Strategy: Project Status at the Half-Way Point*, report DETR/RAS/98.006, May 1998. Back

75 UK stocks of other nuclear materials were also announced including highly enriched uranium (1.61 tonnes) and depleted, natural and low enriched uranium (84,000 tonnes). HC Hansard, 2 June 1998, col. 163-164. Cm 3999, Strategic Defence Review. Back

Select Committee on Science and Technology Third Report

CHAPTER 7: REPROCESSING, PLUTONIUM AND MOX

WASTE SUBSTITUTION

7.46 BNFL wishes to operate a system of waste substitution with its overseas reprocessing customers. This would involve the United Kingdom keeping some extra ILW and LLW as a substitute for a very small amount of extra HLW sent back to other countries. The advantage to BNFL's customers is that they would only need to make provision for the management of returned HLW, rather than LLW, ILW and HLW. Instead of a simple substitution based on radiotoxicity and half-life, the formula proposed for calculating how much HLW should be substituted includes the groundwater return time for radionuclides from a repository. This time has been established for LLW using Drigg, but cannot be estimated for ILW in the absence of an ILW repository. In 1995 the Government said that BNFL could begin substitution of LLW but that the ILW should be returned to its overseas customers if a repository (in the UK) is not available at the time when BNFL is contractually obliged to start sending back the reprocessing wastes, ie 25 years after the wastes have arisen[76].

Views on waste substitution

7.47 BNFL told us that waste substitution would increase the United Kingdom's ILW responsibilities by about two per cent, but that HLW would be reduced by four per cent (Q 128)[77]. Substitution would be radiologically neutral to the United Kingdom and there should be environmental benefits because of a 90 per cent reduction in the transport of wastes. BNFL said that they wished to see the linkage removed between substitution and the availability of a repository (P 289). This point was also made in a recent report by the House of Commons Trade and Industry Committee (11th Report, 1998) which said that, "the inability political as well as technical of the UK system to solve the question of ILW disposal therefore threatens to undermine a major export opportunity". The Committee concluded: "it is important that the question of substitution be recognised as having significant trade implications, and as being very much more than a technical or scientific issue".

CONCLUSIONS ON REPROCESSING, PLUTONIUM AND MOX

7.48 Our concern is with the waste management implications of reprocessing. We are convinced that the reprocessing of spent Magnox fuel should continue, because of the difficulties of storing this fuel for long periods and of disposing of it. Reprocessing of AGR and PWR fuel is environmentally neutral compared to direct disposal but reprocessing of this fuel is not valuable as a waste management method unless the separated plutonium can be recycled or re-used.

7.49 The one current use for separated civil plutonium is in the fabrication of MOX fuel. In the much longer term it may be possible to use plutonium in fast breeder reactors. In the United Kingdom our stocks of separated plutonium far exceed the amounts we could use as MOX in our own reactors or that we might wish to keep as a strategic resource for a future fast reactor programme. We have no reactors which can use MOX at present. The amount required as the initial charge in the core of a 1 GW(e) fast reactor is about 4 tonnes; our stocks of civil plutonium could reach over 100 tonnes by 2010.

7.50 There is no reason to continue to store plutonium which is surplus to all foreseeable requirements. Furthermore if any plutonium is to be declared waste it is necessary to know the quantity to be so declared soon, because of its implications for repository capacity and hence site selection.

7.51 We therefore recommend that the Government develops, as soon as practicable, a clear policy on the long-term management of the United Kingdom's plutonium stock. Our view is that this should consist of maintaining a minimum strategic stock of civil plutonium and declaring the remainder to be waste. Surplus defence-related plutonium should be declared formally to be waste and plans made for its long-term management.

7.52 The principal waste management issue raised by the reprocessing of foreign fuel is that of substitution. Our recommendations in Chapter 6 imply that a repository for ILW is unlikely to be available within 25 years from now. Under present government policy on substitution, this would mean that BNFL would probably have to return ILW to foreign customers, rather than substituting HLW. We recommend that Government re-examines this policy in the light of the more recent work by RWMAC and the 11th report of the House of Commons Trade and Industry Committee.

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76 Cm 2919. Back

77 A 2 per cent increase in ILW volume represents about 3,000 cubic metres of material, whereas a 4 per cent decrease in HLW represents a volume reduction of about 80 cubic metres (based on figures for 2010). Back

Select Committee on Science and Technology Third Report

PART D: SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 8: CONCLUSIONS AND RECOMMENDATIONS

8.1 Our conclusions and recommendations are given at various points in this report, primarily in the final sections of Chapters 4, 5, 6 and 7. In this chapter we draw these together in summary form.

SUMMARY OF CONCLUSIONS

8.2 From our survey of the present situation and its history (Chapter 2) it is evident that the major problem of nuclear waste management in the United Kingdom is the legacy from the past. This and the wastes that are bound to arise when present nuclear facilities are decommissioned dwarf any current projections of wastes from future civil and defence nuclear programmes. The legacy has to be dealt with, whether there are future programmes or not.

8.3 Our technical analysis showed that the current United Kingdom strategy for management of long-lived wastes is fragmented: the approach for existing intermediate level waste differs from that for high level waste and the approach planned for some future arisings of intermediate level waste is different again. There are materials which are held pending decisions on whether they are to be re-used or declared wastes. This is unsatisfactory: to proceed with the siting and design of long-term stores or repositories it is essential to know what wastes will be placed in them. We concluded that an integrated strategy is needed for all long-lived wastes and decisions are needed soon on which materials are to be declared wastes (paras 4.47 and 4.50).

8.4 Of the many methods for the long-term management of nuclear wastes that have been suggested and studied world-wide, only two are now being advocated (see Chapter 3). We found that the majority view from the scientific and technical community is that wastes should be emplaced in deep geological repositories. The minority view, held particularly by members of environmental pressure groups, is that wastes should be stored on or near the ground surface indefinitely, while a research and development programme is conducted to find the best means to manage them in the longer term.

8.5 In our technical analysis (Chapter 4) we examined the range of courses of action which the United Kingdom could follow, from early geological disposal to indefinite storage. We have concluded that the preferred approach is phased geological disposal in which wastes are, following surface storage, emplaced in a repository in such a way that they can be monitored and retrieved. The repository would be kept open while data are accumulated, and only closed when there is sufficient confidence to do so (paras 4.48 and 4.49).

8.6 It is possible that more than one deep repository will be needed to take all our wastes. We will not know whether this is the case until decisions have been taken on materials to be declared waste and until a new site investigation and selection process is underway. Waste quantities can then be matched to site capacities. It is important that one or more deep repositories are operational in the United Kingdom within about fifty years from now. If there is no operational repository by this time there would need to be a major programme of replacement or refurbishment of surface stores, perhaps with repackaging of wastes. This would be in addition to the programme of construction of surface stores which is needed over the next two decades to hold existing wastes (paras 4.50 and 4.51).

8.7 Public acceptance of a national plan for the management of nuclear waste is essential and it has to be achieved at the local level (ie close to potential repository sites), as well as within the country as whole

(Chapter 5).

8.8 Openness and transparency in decision-making are necessary in order to gain public trust, but they are not in themselves enough. Mechanisms must be used to include the public, or groups within it representing a wide spectrum of views, in decision-making (paras 5.40-5.42).

8.9 At the local level, offering compensation for blight and benefits in exchange for hosting a national disposal facility would do much to achieve acceptance (para 5.44).

SUMMARY OF RECOMMENDATIONS

8.10 We recommend that the Government should develop a fully comprehensive policy for the long-term management of all nuclear waste. The policy should have explicit endorsement by Parliament, as well as a large measure of public acceptance (para 6.53).

8.11 The policy has to be the subject of wide-ranging consultation. The Government should issue a Green Paper which states the problem, the possible solutions and the principal means for implementation of that policy, including, for deep repositories, the site selection process. The consultation on the Green Paper should involve as many sections of the public as is feasible. At the end of it the Government should publish a White Paper and report the results to Parliament. There should then be a Bill to establish the policy and the institutional framework for implementing it (para 6.54).

8.12 We recommend that a new organisation be set up to oversee the implementation of policy. This should be a "Nuclear Waste Management Commission", which is outside day-to-day government and which has authority and permanence. The workings of the Commission should be as open as possible. There would be advantages in setting up the Commission initially in a non-statutory way and giving it the task of consultation on a comprehensive policy. The Bill which establishes the policy should give the Commission powers of oversight (para 6.55).

8.13 If, as we think it should, a phased approach to geological disposal is adopted, another new organisation should be set up with the remit to design, construct, operate and eventually close the repository (or repositories), conducting R&D as necessary. The organisation should monitor the repository and should be able, if necessary to retrieve the waste. This "Radioactive Waste Disposal Company" should be a nuclear industry organisation (including the Ministry of Defence), which needs approval from the Commission for its work programme and which works in an open way (para 6.57).

8.14 When there is agreement on the national strategy a comprehensive research programme should be set out, linked to milestones in the development of facilities. The Commission should be responsible for co-ordinating all United Kingdom research on the long-term management of nuclear waste and should take over this role during the consultation period. The safety standards for repositories should be revised and expanded as research and development proceeds (paras 4.52 and 6.59).

8.15 The process of selecting a repository site (or sites, if more than one repository is needed) should be open and transparent, and should involve Parliament and Government. The Commission should oversee the Company's selection of the preferred site or sites. The Company's site choice should be debated in Parliament and examined at public inquiry. The final decision should be made by the Secretary of State (para 6.60).

8.16 The Commission should be financed by means of a segregated fund, derived from a levy on the whole nuclear industry (civil and defence). The Commission should consult those concerned about the desirability and practicability of funding repository development, operation and closure in a similar way, and make recommendations to Government (para 6.61).

8.17 When the Commission is set up some changes should be made to regulatory arrangements. The

Environment Agency should be given a new statutory power over the storage of wastes on nuclear licensed sites. Efforts to bring all Ministry of Defence sites under the full civilian regulatory regime should be intensified and the Government should bring forward a timetable for achieving this objective (para 6.62).

8.18 For the present, Nirex should be maintained, but when the Commission and the Company are established its roles should be subsumed by them. When the Commission is set up RWMAC should be disbanded (para 6.58).

8.19 Small users of radioactive materials should commission a study of the options for management of the limited quantities of short-lived ILW they produce. They should then propose their preferred option to regulators and Government (para 4.53).

8.20 Plans should be made for the establishment of a new LLW disposal facility, to open before Drigg closes. The Government should also consider alternatives to landfill disposal of less active LLW and produce a national policy that is accepted by all concerned (para 4.54).

8.21 When policy consultation is complete, and if the chosen policy is phased geological disposal, this country should take a lead in discussions on international regional repositories and offer help to those countries that need, but lack the resources, to develop them (para 6.63).

8.22 We recommend that the Government should develop a clear policy for management of the United Kingdom's stock of separated plutonium. Our view is that this policy should be the maintenance of the minimum strategic stock, and the declaration of the remainder as waste (para 7.50).

8.23 The Government should re-examine the policy on waste substitution, in the light of our recommendations and the 11th report of the House of Commons Trade and Industry Committee (para 7.51).

8.24 We recommend that the Government acts without delay. The programme for repository development is a long one and cannot be rushed. Delay in starting the programme entails risks and additional costs which an early start to policy development and implementation would avoid (para 6.64).

Select Committee on Science and Technology Third Report

APPENDIX 1

Sub Committee II (Management of Nuclear Waste)

The members of the Sub-Committee which conducted this enquiry were:

L. Craig of Radley
E. Cranbrook
L. Flowers
L. Gregson
B. Hogg
L. Howie of Troon
L. Jenkin of Roding
B. Nicol
L. Phillips of Ellesmere (Chairman until 23 April 1998)
B. Platt of Writtle
L. Tombs (Chairman from 23 April 1998)

The Sub-Committee appointed as its Specialist Adviser:

Ms Marion Hill, WS Atkins plc

In accordance with the rules of the House, Members declared interests as follows:

Lord Gregson: Chairman of the Final Appeals Board of the Compensation Scheme for Radiation-Linked Diseases.

Lord Jenkin of Roding: (a) in respect of his former position as Secretary of State for the Environment (1983-85) concerning appointment of members to Radioactive Waste Management Advisory Committee (RWMAC) and other nuclear responsibilities; (b) Council member of the UK Centre for Economic and Environmental Development (CEED) and (c) member of the UK Advisory Board of the National Economic Research Associates until 30th September 1998.

Baroness Hogg: (a) Director of the Energy Group; and (b) Chairman of London Economics.

Lord Tombs: (a) Honorary member of the British Nuclear Energy Society, (b) Council member of the UK Centre for Economic and Environmental Development (CEED), (c) Chairman, South of Scotland

Electricity Board, 1974-77, (d) Chairman, Electricity Council, 1977-80.

Select Committee on Science and Technology Third Report

APPENDIX 2

Call for evidence (Published November 1997)

The House of Lords Select Committee on Science and Technology has appointed Sub-Committee II, under the chairmanship of Lord Phillips of Ellesmere, to conduct an enquiry into The Management of Nuclear Waste (civil and military) in the United Kingdom.[78]

We are particularly keen to hear of international experience with nuclear waste management issues where there has been success in finding technical solutions and achieving public acceptance. All management options are under consideration (including storage, repositories and transmutation of waste), but we **do not** intend this enquiry to cover the future of nuclear power per se, nor the management of waste stocks other than those arising in the UK. The enquiry will focus to a large extent on the management of intermediate and high level waste rather than low level wastes.

The Sub-Committee has access to the new report by the Parliamentary Office of Science and Technology Radioactive Waste - Where Next? (POST, November 1997) which provides a useful summary of nuclear waste management issues and a discussion of the problems surrounding the proposed Sellafield repository. The POST report will be taken as a starting point by the Sub-Committee and answers to questions should be framed with this in mind so as to avoid unnecessary duplication of work. The POST report can be purchased from the Parliamentary Bookshop or from The Parliamentary Office of Science and Technology, 7 Millbank, London, SW1P 3JA (tel: 0171-219 2840).

We invite written submissions on all matters relevant to this topic, but in particular to the questions listed below, with a view to making a report to the House of Lords and the Government in the summer of 1998.

1. What is the best **sustainable solution** for the long-term management of nuclear waste in the United Kingdom? By what process should this be ratified? Is there an adequate knowledge base to support such a solution?
2. Are you satisfied with the **institutional responsibility** for nuclear waste in the United Kingdom, and, if not, how might it be improved?
3. How should the **process** of storage and/or repository site selection be conducted to reduce conflict and to ensure that work can be carried out at sites that are agreed to be acceptable? Who should be involved?
4. It is perhaps unrealistic to assume that the >perfect site for a long-term store or repository can be found (or even exists), so what would make a good nuclear waste site:
   i. What **selection criteria** should be used?
   ii. How should these criteria or other performance attributes be **compared**?
   iii. If a repository option is chosen, what solution would be **acceptable in geological terms**?
5. How can a rational assessment of the risks associated with a long-term nuclear waste store or repository site be made, and how can one be sure that what is an acceptable risk now will remain so in the future? How do the principles of intergenerational equity apply?
6. What is the **standard of safety** to which a repository or long-term store should be designed? Is there a firm public perception that it should be Aas safe as possible regardless of cost, and if so what are the implications?
7. Has enough been learnt from the experience of **natural analogues** to determine the optimum design and geological conditions for a nuclear waste facility?

8. What are the problems and advantages of instituting a waste management programme where intermediate and high level waste are dealt with together, i.e. in a **co-disposal** repository?
9. Would an **international solution** to nuclear waste management be desirable and feasible (e.g. a joint repository accepting waste from many countries) and if so what would this entail?
10. Can we **postpone** the search for a repository site in the United Kingdom and simply maintain existing arrangements? Might more emphasis on waste **partitioning** and **storage** be used both to defer and to reduce the requirement for a repository?
11. Does the management of UK **military** nuclear waste present any special problems?
12. What measures should the UK take to sustain the long-term **research base** for the management of its nuclear waste?

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78 Lord Phillips of Ellesmere stood down as Chairman 23 April 1998. His place was taken by Lord Tombs. Back

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Select Committee on Science and Technology [Third Report]

APPENDIX 3

WITNESSES

The following witnesses gave evidence. Those marked * gave oral evidence.

*Dr John Adams

*AEA Technology

Dr J A Allison

Australian High Commission

Mr Stephen Balogh

Dr Anthony Batchelor

Mr Peter W Beck

Professor J N B Bell, Professor H S Wheater, Dr A P Butler and Dr G Shaw

Blewbury Environment Research Group

*British Energy

*British Geological Survey

*British Nuclear Fuels plc

British Nuclear Industry Forum

Mr W R Burton

CADNO

University of Cambridge (Department of Plant Sciences), and University of Newcastle (Department of Biological and Nutritional Sciences)

Campaign for Nuclear Disarmament

Mr Jack Catlin

CMA International Ltd

CND Cymru

Consortium of Opposing Local Authorities

Copeland Borough Council

Dr Gary Couples

Professor W J Cram, University of Newcastle

Cumbria County Council

Cumbria and North Lancashire Peace Groups

Cumbrians Opposed to a Radioactive Environment

Dr Robin Curtis

Mr Phil Davies

*Department of the Environment, Transport and the Regions

Mr Ian J Duncan

City of Edinburgh Council

Entec UK Ltd

*The Environment Agency

Environment Council

*European Commission

*Dr David Fishlock

Dr Ron H Flowers OBE

Dr Mark Foster, Department of Plant Sciences, University of Cambridge

*Friends of the Earth

Friends of the Earth, West Cumbria and North Lakes

Friends of the Earth Cymru

Friends of the Lake District

The Geological Society

Golder Associates (UK) Ltd

Gosforth Parish (Cumbria) Action Group

Gosforth Parish Council

*Professor Malcolm Grant, Mr Rory Joyce and Mr Andrew Piatt

*Greenpeace Ltd

Harlow Council

Dr Stuart Haszeldine, University of Glasgow

*Mr Nigel Hawkes, Science Editor, The Times

*Health and Safety Executive

Institute for Resource and Security Studies, US

Institute of Physics

Institute of Civil Engineers

*International Atomic Energy Authority

Irish Government

Joint Trade Unions

*Sir John Knill, FEng

Leeds City Council

*Dr Graham Loomes

Manchester City Council

Dr Charles McCombie

Merthyr Tydfil County Borough Council

Midlothian Council

*Ministry of Defence

*Sir Richard Morris, CBE FEng

National Campaign for the Nuclear Industry

National Co-operative for the Disposal of Radioactive Waste, Switzerland

National Radiological Protection Board

National Steering Committee of Nuclear Free Local Authorities

Natural Environment Research Council

*Nirex

Nuclear Awareness Group

Nuclear Control Institute

*Nuclear Safety Advisory Committee

Nuneaton and Redworth Borough Council

Nycomed Amersham plc

Dr D W Ockenden

Omega Pacific Ltd

Oxford Research Group

David L Pentz

*Dr Nick Pidgeon

*QuantiSci Ltd

*Radioactive Waste Management Advisory Committee

Gisela Renolds

Mr P J Richardson

Professor Lewis Roberts

Rotherham Metropolitan Borough Council

*The Royal Society

Scientists for Labour (Energy & Environment Group)

Scotland Against Nuclear Dumping

Scottish Environment Protection Agency

*Shell UK Ltd

Alan H Smith

Sound Nuclear Initiative

South Lakeland Friends of the Earth

Mr Kathleen Sullivan

Mr Trevor Sumerling

Dr Jill Sutcliffe

Sutherland Shire Environmental Centre Inc

Swedish Nuclear Fuel and Waste Management Co-SKB, Sweden

*Synroc International Limited

Dr B G J Thompson

Mr Clifford G Tonkin

*United Kingdom Atomic Energy Authority

United Kingdom Centre for Economic and Environmental Development

Wales Nuclear Free Forum

Sir Frederick Warner

Mr H J M Warren, Cumbria

*Professor Stephen Watson

Welsh Anti Nuclear Alliance

West Dunbartonshire Council

Mr Raymond D White, in association with Mr David Gutteridge

Professor David R Williams OBE

W S Atkins Consultants Ltd

*Professor Brian Wynne , Lancaster University

Select Committee on Science and Technology Third Report

APPENDIX 4

NOTES ON OVERSEAS VISITS

Members of the Committee made visits to the United States and Canada 14-23 May; Sweden 22-24 June; and France 20-23 October. These countries have significant waste management programmes which, although different from our own, provide a good insight into some alternative approaches. We learned much from our meetings and the establishments we saw. At all locations our hosts were exceedingly helpful and hospitable. We would like to reiterate our thanks to all involved for their assistance.

The conclusions we drew from our visits are incorporated in the body of our report. What follows are notes on some aspects of the meetings at each location.

Note of visits to US and Canada
14-23 May 1998

Members present: Lord Tombs (Chairman), Lord Craig of Radley, Lord Flowers and Lord Howie of Troon, accompanied by the Clerk.

Summary

The Committee held meetings with Federal Agencies and others in Washington and Ottawa, visited the WIPP disposal site at Carlsbad, New Mexico, the proposed spent fuel repository at Yucca Mountain, Nevada, and the rock characterisation facility at Whiteshell, Manitoba.

Meetings with the Federal Agencies in Washington provided useful background for the subsequent visits. At WIPP, a facility started in 1988 and where $2 billion has been spent to date, they were ready to take their first delivery of waste for disposal. There may be delays due to legal action but both on-site and in Washington the majority view was that the facility would become operational shortly. As at February 1999 it had not. The Yucca Mountain project was clearly a lot further from operational status: the demonstration of viability was the next milestone on their schedule. The separate research groups, mostly from DoE national laboratories, did not demonstrate the same single-minded sense of purpose apparent at WIPP.

The visit to Whiteshell showed an apparently very sound and scientific approach to rock characterisation. But the level of activity was low and the need for further generic study of rock in the absence of any decision to proceed towards a final repository seemed in doubt. The meetings in Ottawa tended to confirm these doubts: Canada is in the process of re-evaluating its disposal plans in the context of an overall review of energy (primarily electricity) and environmental policy.

Washington

Non Governmental Organisations

Mr Michael Marriotte, Nuclear Information and Resource Service, was the lead speaker for the NGOs. He opened by saying that in the near term the risks from transportation of nuclear waste outweighed the benefits of centralised waste disposal. There was no need for a central store/repository. The problems of waste had been with us for less than 60 years and would be with us for many centuries. Contaminated sites would take more than two generations to clear. There was no crisis. He added that the last successful order for civil nuclear power had been in 1973 and none was likely in the foreseeable future.

Mr Marc Fioravanti, The Institute for Energy and Environment Research, spoke in favour of a revised classification system, as the US system was not relevant to the long-term hazard. Although he acknowledged it was probably politically unacceptable, he thought, technically, it was worth looking at sea-bed disposal. What was needed now was much more emphasis on research and an examination of all the options. Ms Maureen Eldridge, Alliance for Nuclear Accountability, pointed out that although there had been research on technical solutions nobody had looked at the social/equity issues: they had just looked at Yucca Mountain. The consensus was that responsibility for nuclear waste should be taken from US DoE and given to a new independent agency responsible solely for disposal.

In a discussion of the prospects for WIPP, Mr Auke Piersma, Public Citizen, and the other representatives made the point that it was difficult to take legal cases based on technical issues, where the courts invariably deferred to Government experts, but cases could be won on procedural issues. They would be litigating against the opening of WIPP and the shipment of waste from Idaho and elsewhere.

Ms Eldridge was concerned that the environmental groups had not been able to open up a "natural dialogue" with Government. A forum was needed whereby concerned people could discuss what was technically sound and was fair and equitable. This would take many years to establish. The forum would be like those used for race relations, education and climate change. A new procedure was necessary to enable a comprehensive examination of all aspects. Perhaps a Presidential Commission might be appropriate.

US Nuclear Regulatory Commission

Dr John Greeves gave a presentation on the legal background to the Commission's role in the regulation of waste. Congress had required the Agency to undertake rulemaking. The long-term requirement was well defined but the interim measures were politically charged. WIPP had been decided following a scientific evaluation but Yucca Mountain was chosen for high level/transuranic waste by Congress.

The Agency had 40 people based in Washington and around 50 at the Southern Research Institute. NRC was not aware of any new proposals for re-classification of waste, but there had been many such proposals over the last decade. In practice "greater than class C" low level waste was like UK intermediate level waste.

Twenty per cent of US waste is government owned but the creation of a repository is regarded by NRC as a public good which is rightly paid for by Government. The risk criteria "one in a million" per year would be difficult for Yucca Mountain - as it would for oil production platforms and fossil fuel burning. (Coal ash is treated as a "technologically enhanced natural material" and exempt from the requirements of nuclear waste disposal.) Some DoE sites, eg Hanford, have severe problems but DoE is "self-regulating". Approximately 50 tonnes of weapon grade plutonium may be introduced into the commercial fuel cycle as MOX, but in general the policy was not to pursue this approach or to undertake reprocessing. In practice, a third of the plutonium did not lend itself to incorporation in MOX in any case.

The NRC was optimistic that, after minor legal skirmishes, WIPP would open. However, transportation would continue to create difficulties. If Yucca Mountain failed "we start over", ie NRC was not considering alternative sites. At this time more than two thirds of the House of Representatives were in favour of the Yucca Mountain site but the proposal faced implacable opposition from the Nevada State delegation.

The NRC showed some concern that EPA might promulgate a standard for ground water which would in effect rule out Yucca Mountain as a disposal site. There would be public hearings on these rules and the distance from the site at which they should be applied.

Nuclear Waste Technical Review Board

The Board had been created by Congress specifically to advise on the Yucca Mountain project. It met three or four times a year in public, had a staff of 15 - half of whom were technically qualified - who organised various ad-hoc sub-committee meetings primarily on technical issues. The Board was appointed by the President, but for terms which straddled presidential elections, and members were nominated on advice from the National Academy. The Board was regarded as independent - not political. It was purely advisory and had no executive powers.

The Attorney General for the State of Nevada and the congressional delegation were strongly opposed to the Yucca Mountain site and EPA, if it promulgated a health based standard comparable to the drinking water standard, would stop the project. But science was only part of the issue, public acceptability was crucial.

In a discussion of the role of the public it was pointed out that 95 per cent were not active participants but, in this case, the passive majority were content to follow the lead of the environmental end of the spectrum, not the Government or the industrial scientists. DoE had awoken too late to the importance of the issues of public perception. The role of Congress was to integrate these views of the public but whereas Congress took an active role in some environmental issues this was not one.

US Department of Energy

Jim Owendoff, Program Director, WIPP described DoE's work on waste treatment since the early 50s. They had been working on WIPP for over 23 years and, although there would undoubtedly be Federal and State legal suits, he was optimistic that it would become operational shortly.

Discussing work on acceptability issues, Ernest Moniz, Under Secretary said the Department had not adopted a high national profile. The New Mexico State Delegation supported WIPP but that from Nevada was very hostile towards Yucca Mountain. The Department was not considering any alternative to Yucca Mountain unless the site was ruled out: the legislation passed by Congress in 1987 to establish Yucca Mountain as the repository stated that DoE may not search for any other site. Storage, currently designed for 100 years, could be extended to, say, 200+ during which period there might be a "monitored repository" - but ultimately closed disposal was the objective. The problem was not a technical but a social one. The "interested public" was very negative towards nuclear power and a waste repository in particular.

The Department undertook some research on waste minimisation and transmutation but although these techniques might postpone the need for a repository, but they could not replace it. Transmutation would be a good programme for international collaboration. If it could be shown to work it would help with the public perception and may reduce the long timescale of disposal, but was not a solution to the present problem.

New Mexico

Waste Isolation Pilot Plant

George Dials, the DoE Area Office Manager argued that surface storage of waste was unsatisfactory in that natural hazards, weather (in particular tornadoes) could lead to dispersal - and there was always the need to prevent unauthorised access. In 1971 the Atomic Energy Commission (a predecessor of DoE's in the area) had selected a rock salt deposit in Kansas for disposal but this was technically inadequate. The present site was geologically vastly superior and was politically acceptable.

In the US many contaminated sites were close to centres of population, for example Rocky Flats was near the 3 million people of Denver. Within ten years of becoming operational, WIPP would reduce the number of people within 10 miles of such radiological hazards from 53 million to 4 million. In 1980 they had a congressional mandate to "study the problem" but the study was now over and the objective was to become operational. Waste would be transported from almost every State of the Union: traffic accidents were the greatest risks.

In commenting on the significance of transportation, Mr Dials observed that relative to leaving waste where it was - moving it was better. He noted that in Texas the civil authorities had decided that the risks from transportation were so small that no special action was needed. However, in Santa Fey concerns had resulted in funds to build a by-pass. Concerning the legal challenges to WIPP, Mr Dials was confident: the EPA had approached the WIPP rule-making process in the knowledge that they would be sued. He was certain the rules would withstand the legal challenges.

Touring the site itself revealed a very business-like approach to construction. Tests had already been undertaken on the collapse of salt caverns. The Committee saw the way the roof bowed as caverns opened earlier tended to refill. The site created the impression that it would shortly be an operational facility where the day-to-day business would be the disposal of waste.

Nevada

The Yucca Mountain Project

Mr Alan Benson, Director of Institutional Affairs, provided an introduction to the Yucca Mountain project. Work had begun in the early 70s with the decision of Congress. It had created very strong local opposition. The area had been subject to earthquakes and prior to that was a volcanic region. But they have found nothing to indicate that it was unsuitable for disposal. Congress had offered Nevada $100 million per annum but this had been rejected. Now there was a congressional enquiry into the way monies had been spent, reflecting the political conflict over the choice of site. The Yucca Mountain site budget was $346 million per annum of which $194 million came from the Defence budget. The total cost of the project was likely to be around $9 billion if it proceeded to completion. However, even if the next stage was completed satisfactorily, the State of Nevada could submit to Congress a "Notice of disapproval" which would need a congressional vote to overturn.

The jurisdiction over the Yucca Mountain site was complicated. One third lay within the Nevada test site and the remainder was shared between the adjacent Air Force base and land belonging to the Bureau of Land Management. The site was chosen primarily for its remoteness and the technical facilities - those associated with a nuclear weapons test site. Underground we were shown the work which has just been completed on heat testing to simulate waste fuel rods in situ. No radiation tests had been undertaken and the effects of exposure of rock, eg expansion, had not been determined. Although we were 400m above the water table (and a similar distance below the surface) water was present in the rocks and dripped from the ceiling when it was heated.

Winnipeg

Whiteshell Laboratories

The Committee was welcomed by Dr Ken Dormuth, Director of AECL's Environmental Studies, who gave us a presentation on the work at the site. CANDU fuel bundles are currently stored at generating site. There are about 1.3 million of them which, assuming no further power stations are built, would rise to about 3.6 million. Most were in Ontario and spent a few years underwater after which they were dry stored. Current storage presented no problems, not even in the mind of the public. But such storage was unsatisfactory in that it depended on institutional controls, people to maintain security and undertake monitoring etc. Dr Dormuth observed that you cannot say something was "safe" if it relied on people to maintain security. There needed to be a stable society to operate a store that required maintenance or allowed retrievability. If there was any hint of a lack of such stability, economic collapse etc, then the first item to be cut would be expenditure on safe storage for future generations.

The Federal Government and the Ontario Provincial Government had established a nuclear fuel waste management programme to look at disposal. The legislation establishing this programme had defined disposal with no intention of retrievability. If a disposal site were left open security would create the major risks. In 1978 a site was chosen and a programme initiated but it was a demonstration site, not a permanent repository. Public acceptance was based on the assurance that it would not be the chosen site. Public debate over who would decide the location of a permanent store meant that in 1988 a public review was initiated. The present site had been intentionally located where faults were present to examine their effect. There was no information on any putative sites. Public concern over the "seal and walk away" concept had put the brakes on the programme.

AECL had been instructed to produce a generic environmental impact statement addressing safety and intergenerational equity issues. It was based on a "concept" not a specific site. However there were many potential sites within the Canadian shield. The Ministry of Natural Resources, to whom AECL as a Government Agency reported, had referred the matter to the Ministry of Environment which had appointed a review panel (the Seaborn Panel). The remit of this panel was to review the safety and acceptability of the concept along with "a broad range of nuclear fuel waste management options".

Dr Davidson described the hydrological research undertaken at Whiteshell. Again studies had been undertaken on a "hypothetical" location bearing in mind this was generic work not aimed at a specific site. They had demonstrated that their models were good at predicting reality but 'generic' research was no substitute for work at the actual proposed site. All hydrological work was now shelved pending a decision on the future of the laboratory.

Dr Ohta described the underground research laboratory stating that the original concept was a precursor of a repository but this had quickly been changed to a generic laboratory. The site was finally chosen to enable fractures etc to be examined. There were around 70 people on the site, it had cost C$72 million for construction and the total spend was about C$160 million. Construction finished at the end 1980 and since then experiments on, for example, heat dissipation, engineering barriers, buffer stores and tunnel sealing had been undertaken.

Our visit to the site revealed a superbly clean underground laboratory. The walls were washed, there was hardly any dust present, the surface underfoot and lighting levels etc were all first rate. There were display boards to describe the experiments that had been undertaken: but there was little work in progress.

Ottawa

Atomic Energy Control Board

Dr Agnes Bishop, President, described the Board's role as an independent regulator. She quickly developed the theme that it is "public acceptance" that is the problem in regulating nuclear waste for most countries. She stated that even if you solve the disposal problem, the public perception of the transportation risks raised at least equal difficulties. Although AECB had no definition of what "acceptable to the Canadian public" meant, it had clear consultation procedures involving elected representatives and public hearings. There were no rules about who had to be consulted or even agreement about who might create such rules. Dr Bishop observed that if the politicians were affected by "public concern" - then such concern was real and relevant.

Dr Bishop observed that the environmental assessment of a future site required the answer to questions that were site specific - information that could only be obtained once work on the site had commenced. However these issues were perhaps secondary: politicians and policy-makers were deeply concerned by the public attitude and until all this was resolved there would be no disposal.

In discussing internationally shared facilities the general view around the table was that if one nation demonstrated that it could solve its own problems then there might be an opportunity for shared disposal facilities. But until then, an international solution was unrealistic.

Natural Resources Canada

A large round-table discussion was held at Natural Resources Canada chaired by Dan Whelan, Director General of the resources branch. Also present was Peter Brown, Head of Radioactive Waste Policy; Blair Seaborn, the Chairman of the report on Nuclear Fuel Waste Management; and Brennian Lloyd of the Public Interest Group, Northwatch. Mike Clelland, Assistant Deputy Minister, joined the meeting part way.

Dan Whelan opened the discussion by explaining that Ontario Hydro had closed seven reactors (leaving 12 remaining) because of management problems. Dr Whelan said that in Canada the public was no longer content that the industry could handle its problems - from proliferation to waste.

Peter Brown stated that in 1976 the Government adopted a report which examined the choices for waste management and concluded that phased geological disposal was the way forward. Granitic rocks in the Canadian Shield were the first choice with salt secondary, primarily because the United States was undertaking any necessary work. Both the Provinces and the Government had concluded that no disposal could proceed until the concept was acceptable to the public. In 1988 AECL came forward with a technical concept and a panel, subsequently known as the Seaborn Panel, was formed.

The Government would probably respond the Seaborn report in the Autumn. It may set up a new agency to deal specifically with waste, there would be a new Regulatory Control Act in place and Government would consult on the detailed regulations. The response to the Seaborn report would probably be associated with a wider review of the future of nuclear power and its role in energy production.

Richard Ferch described changes underway to the 1946 Atomic Energy Control Act. This set up the Atomic Energy Control Board with the power to grant licences and set conditions on radioactive substances. He emphasised the importance of public participation in defining requirements for the environmental assessment. There were legal requirements on participation and in practise a political need for public acceptance. The Government had set regulatory objectives for disposal facilities: risks below 10^{-6} to an individual with no credit taken for institutional controls etc. Mine tailings, for example, did not reach these criteria as institutional controls would be necessary indefinitely.

Dr Blair Seaborn described the work of the Waste Management and Disposal Concept Panel. The Panel's terms of reference had been to examine the concept of deep disposal in a rock repository. It was asked to comment on the safety and acceptability of this concept and provide advice on what policy Government should follow.

Dr Seaborn described the recommendation of the Panel that Government should issue a policy statement on nuclear waste management. This was to enable Canadians to know what the Government thought and what its objectives were. The public could then make its own conclusions on where a specific disposal site might fit in with that policy. The panel had recommended the establishment of a special agency to deal with nuclear fuel waste, improved consultation methods in general and a specific, comprehensive plan for public consultation on disposal - this would probably be the first job of the new agency. This agency should be operational within one year and able to make recommendations to Parliament in three.

Dr Seaborn made it clear that "sufficient" consultation should probably be measured in terms of time and intensity, ie a review period of a certain duration involving certain procedures. It was the role of Parliament to gauge the outcome of such consultation. Dr Seaborn commented that it was not meaningful to ask the public "Do you like this?", eg underground monitored retrievable storage, when the question was not asked with reference to anything else, ie, compared to surface storage etc. Although it was advocated by many environmentalists, there was no data on long-term surface storage. Until more work had been done on all these processes the Panel had recommended that a specific site should not be sought.

Dr Seaborn made it clear that failure to demonstrate acceptability was not synonymous with a clear indication of unacceptability. The onus was on the proposer to show that the proposed course of action was acceptable. The public had shown by its rejection of previous proposals what was not acceptable. Dr Seaborn indicated that far greater political involvement was needed, perhaps by a joint Senate House Committee.

A decision was needed within the next three years not on the "best" site but on one which was acceptable to the host community (however defined). The involvement of the "willing host" would have to be a continuing process with the community participating in local decisions. In practice the distinction between a deep repository and a retrievable store need not be great. But in the minds of the public it was probably significant. If retrievability existed the assumptions, the models etc, could be checked and, if found acceptable, then one could say, "Okay lets close it".

Brennian Lloyd made it clear that from her public interest perspective the linkage between nuclear power and nuclear waste was not worth attempting to unbundle. An energy strategy was needed which would provide emphasis on conservation and renewables. Nuclear energy was not a response to global warming.

Note of visit to Sweden
22-24 June 1998

Members present: Lord Tombs, Lord Craig of Radley, Lord Flowers, Baroness Hogg and Lord Jenkin of Roding, accompanied by the Clerk.

Summary

The Sub-Committee visited Sweden to meet Government officials in Stockholm and the facilities of SKB at Forsmark and Oskarshamn. A note of each meeting follows this section.

Sweden has had an underground repository for "operational waste", that is short-lived low and intermediate level waste, since 1988. There have been two attempts at selecting a site for a deep repository for spent fuel, so far without success. But the last attempt failed to win acceptance only narrowly and since then the Swedish Government has re-doubled its efforts to gain public support. SKB has completed generic research on rock characterisation and is undertaking the technology development, handling, and staff training necessary to run a repository.

The Swedish waste disposal problem is inherently more straightforward than our own. They have elected not to reprocess spent fuel and therefore do not have all the intermediate level waste or plutonium associated with that process. Co-disposal of short-lived waste, and disposal (not re-processing) of spent fuel is both technically and presentationally more easy than our own task. Their society is also different: allegations of secrecy seem rarely levelled at the industry and even less at the regulators. Part of the public confidence in the regulators may stem from the Swedish freedom of information laws. But even with a history of public confidence in the nuclear industry and its regulators, the absence of a nuclear waste legacy from past military programmes and a more straightforward waste management programme with its absence of reprocessing, Sweden has not yet gained public acceptance for a deep geological disposal facility.

Stockholm

Swedish Nuclear Power Inspectorate (SKI)

Mr Lars Högberg, Director General told us that in Sweden about 50% of electricity is generated by nuclear power, giving a per capita figure greater than the French. SKI regulated reactor safety, licensing etc, as well as non-proliferation matters. It had a staff of 111 and was responsible for ensuring the conformance with licensing conditions. The Swedish Radiation Protection Institute (SSI) enforced environment conditions, water standards etc.

The Swedish constitution in 1766 gave public access to the documents of "The Authority". In effect Sweden had the equivalent of a Freedom of Information Act giving individuals the right of access to regulators. SKI ensured that the nuclear industry published relevant documents.

Mr Högberg outlined the objectives for the safety of nuclear waste: future generations should not be asked to tolerate greater risks than the present, and responsibility for waste should be met by those who benefited from its creation. He saw the challenge under four headings: financial, scientific, technical and "democratic", ie, societal issues.

Financial issues were straightforward. The generators were required to contribute to a fund which was approximately Kr25 billion. The scientific and technical issues were also relatively clear. In the course of a regulatory review of the entire disposal process, projecting forward to a hundred thousand years, SKI had concluded that the radiological risk of disposal was similar to that in present rocks. There was what he called a "reasonable assurance of a tolerable risk facility", ie a satisfactory disposal facility could be built.

But societal issues were the challenge. These required first an acceptance of the safety criteria and the concept of "reasonable assurance"; then there had to be acceptance of the choice of system, ie, disposal, transmutation etc and finally there had to be acceptance of the site, the design and construction of the repository. These were national decisions which could not be taken solely at local level. "You cannot expect local communities to take national decisions".

Mr Högberg felt that SKI was trusted by the public who recognised that the scientific and technical capabilities of the organisation gave it independence. Regulations were developed in a step-wise manner which involved local elected officials.

Swedish Radiological Protection Institute (SSI)

Dr Karl-Magnus Larsson, Director described the work of SSI. In effect the organisation combined the roles of our NRPB, examining the science of all forms of radiation, electromagnetic, ultra-violet, etc. It was also responsible for environmental protection. In the case of a repository, SKI had the overall co-ordinating responsibility but SSI had responsibility for the radiological protection element. The decision on licensing rests with the Cabinet.

SSI had a specific mandate to inform the public and explain the issues of radiological protection. The public had developed now a better understanding of the issues and was "asking tougher questions" The organisation undertook its own research as well as commissioning work from others. Dr Larsson maintained that a decision on the need for monitoring of a repository could be taken around the time of prospective closure, ie, 2050/2060. At present there was no need to debate the issue, for interim storage would certainly have to be used for spent fuel.

National Co-ordinator for Nuclear Waste Disposal

Dr Olive Söderberg explained the role of the organisation. His post had been created for three years, he had a staff of three people and a budget of around Kr3 million. He set up discussion fora to enable local municipalities to understand the issues. It was the responsibility of industry to find a solution and implement it, but this obligation could not be fulfilled unless the public understood the need for a long-term repository. It was a question of creating understanding and with it trust: not just providing information.

Dr Söderberg's work was funded from the nuclear waste fund. He had established a "Nuclear Environment Assessment Forum" for nuclear waste disposal consisting of a committee of 25 people including regulators, industry, municipal officials, theologians etc. They looked at issues such as alternative strategies, siting and societal questions. Alternative strategies were examined from the ethical view point: what should be left to succeeding generations. Often these topics created difficulties for local politicians who were elected to protect their local community. Nonetheless, Dr Söderberg was confident that it would be possible to find a suitable and willing local community to accept a repository. Indeed there were plans to provide financial compensation to those who underwent a feasibility study but did not end up with a repository, ie, compensation for loss of benefit for those passed over in the competition to house the repository. But there were no financial inducements for hosting the repository.

Dr Söderberg reiterated the general consensus that public agreement had to be achieved before contemplating even a feasibility study. Initially volunteers had been sought throughout the nation but SKB concentrated on those near existing nuclear plants. It took one and a half years for Oskarshamn to decide it would accept a feasibility study and Government was looking for approximately five such studies. It takes a long time to gain support and the Mayor of Oskarshamn spent about 50% of his time on the issue of the repository. Public acceptance could not be rushed. There was an overwhelming lack of interest by local communities in nuclear issues until a site was proposed in their municipality. Only this created the awareness which was then perceived in local, not national terms.

Swedish National Council for Nuclear Waste (KASAM)

Dr Camilla Odhnoff is Chairperson of KASAM, an independent Committee established in 1985 to study issues relating to nuclear waste and decommissioning. It reports to the Minister of the Environment, who appoints the chairperson. This Committee is also widely drawn to include not only experts on the science and technology of radioactive waste disposal but also those with expertise in ethics, law and social sciences. Review of the research and development programmes for the repository is within its remit. KASAM produces its report on the state of knowledge every third year, although its existence is not widely known to the public.

Forsmark

Swedish Nuclear Fuel and Waste Management Company (SKB)

The Sub-Committee was welcomed by Dr Claes Thegerström who told us surveys showed that the public had confidence in the regulators and an even greater confidence in SKB. There was a general "trust in the system". This he put down in part to the transparency of the process and the Swedish equivalent of freedom of information. In Sweden there had been no adverse nuclear power events and confidence in the industry had recovered rapidly following the Chernobyl incident. He did not think the political decision to phase out nuclear power had any effect on the acceptability of a nuclear waste repository. However, at present there was no prospect of any new nuclear generating capacity being laid down.

Government had set clear responsibilities for SKB. It was an entity of the producers who were responsible for its funding. It undertook R&D and demonstration projects, was responsible for site selection, planning and construction of the repository and would be responsible for its commission and operation. In the end only the State can assume long term responsibilities for matters over hundreds or thousands of years but up to the point where no new safety measures are required, it was SKB's responsibility.

SKB had been formed in 1972 for joint uranium purchases by the power producers and by 1977 had become involved in waste treatment. The repository at Forsmark had been in operation since 1988. Dr Thegerström said that if you had a step-by-step process, and you were able to take a step backwards if needed at no unreasonable cost, you would, in the end, have sufficient confidence to walk away from a deep repository. However, the uncertainty about future social change was orders of magnitude greater than uncertainty about any technical issues.

Dr Tönis Papp, Research Director described the three-level hierarchy of safety: isolation; retention and dilution, which was the basis of their philosophy. Waste was put in steel containers encased in copper which were placed 300-500 metres below the surface in crystalline rock and back-filled with bentonite clay. The objective was to have a system which was not dependent on maintenance but which did not hinder monitoring.

In analysing safety, he said it was important to show the absolute maximum risk achieved rather than dealing with mean values and quoting a scatter band. To enhance the demonstrability of their systems they relied on existing naturally occurring materials, for example, items such as bronze cannons which had been on the sea bed for over three hundred years, or old copper coins.

Maximum container temperature was kept low, (80-100°) and materials were not operating far from their "normal" range, although the welding of the containers, particularly the steel case, was critical. It was also important to show that retrievability and monitoring did not reduce safety. Retrievability might be necessary even without a monitoring programme if, for example, more knowledge on welding technology suggested that the safety case had changed and material should best be removed. Dr Papp accepted one could question the behaviour of materials in the long-term, particularly under radiation, but this was the best situation based on present knowledge. If waste was left on the surface a breakdown in society was a far greater potential for harm.

Mr Claes Thegerström, Vice President said in 1992 SKB wanted to commence construction of a repository. They needed homogenous bedrock with no minerals which might prompt exploration, an industrial facility on the surface, good transportation (all reactors are on the coast and they have a specialised transport ship) and above all public acceptability. Two overriding principles were safety and acceptability - to get political support the politicians needed to have public support.

SKB would look for five to ten sites where they could undertake feasibility studies, select two from these, undertake a drilling programme which might last five years or so and then go through a formal licensing procedure for detailed site exploration at one. They had sufficient knowledge of Swedish geology to conclude that about half the country was suitable for a repository. At the first site they had examined, a referendum showed that approximately 70% were against, but the second site considered in 1977, showed 54% against with 44% in favour. SKB had spent about £1.1 million on this second site, but had now forsaken it in the light of the referendum. (The local community had in practice a right of veto.) The main lesson learned was to start early.

Mr Torsten Eng gave details of the current feasibility study. A main element in their discussions at local level had been the need for a national indication of support: hence the role of the national co-ordinator. The national environmental groups had stated that they were against geological disposal on principle: more research was needed, not a siting exercise. The Government concluded that as they did not agree to the principle they should leave the national co-ordinating group, which they did.

Mr Bo Kåwemark, Operational Manager of the Final Repository for short-lived waste (SFR) described the facility, 50 metres below the surface and one kilometre from shore under the Baltic Sea. Construction had started in 1983 and was completed by 1988. It had a capacity for 60k m^3 of which 22 had been filled so far. About Kr740 million had been invested and the operating costs were around Kr25 million per year. If necessary the facility could be extended by building new silos: these were 25 metres in diameter and 50 metres high. Waste was laid down in 42 layers, back-filling every three with concrete. By 1996 they had emptied all interim storage in Sweden and the pace of filling had now slackened off to match disposal requirements until 2020.

Our visit underground revealed a very impressive facility: a tunnel with high-ceilings and a good road surface, well ventilated with all services installed to a very high quality. It was cool, quiet and damp (700m^3 of water per minute were pumped out).

Oskarshamn

Canister Laboratory

Mr Henry Gustavsson is the site manager of the Canister Laboratory where development work is undertaken on the canisters to be used to hold the spent fuel rods in the repository. It is situated in a large building on the docks at Oskarshamn next to where the SKB transport ship, Sigyn, is moored. The facility, which cost Kr150 million, will be a demonstration model of the technology used to seal the containers, covering all aspects except the actual placement of active fuel rods. Cylinders are sealed, welded with an eb welder, examined by x-ray, ultrasonically tested and finally made ready for dispatch.

The Laboratory has already shown around over 500 members of the public and has produced a very good video. As with everything we saw, the standard of construction of the building, all accessories and fittings, was particularly high. Although referred to as a "laboratory" the facility was more like a pre-production prototype designed to test operational equipment and handling.

Äspö Hard Rock Laboratory

Dr Olle Olsson is Project Manager of the Äspö Hard Rock Laboratory. From the surface the Laboratory looks uncannily like a small modern Swedish farmhouse and associated barns. The majority of red-timbered buildings were built in 1994 although the "admin" building was constructed only one month ago. SKB had started work in Äspö in 1986 to extend their generic knowledge base. They needed a better performance assessment of rock characteristics and to develop and test the methods they might use for disposal. The facility would also be used for staff training. The Laboratory had been located near a power plant to make use of the infrastructure and a site with a variety of conditions (rock faults etc) chosen to evaluate techniques. SKB had given an undertaking to the local community that they would not put the final repository at this location.

There had been a pre-investigation phase, 1986-1990, and construction from 1990-1995. They had been operating since then. The Laboratory consisted of a road and shaft to 420 metres, constructed by drill and blast techniques, at which level they had used a tunnel-boring machine to open out the chambers. As at Whiteshell, we saw work on sealing technology, barriers and back-fill materials etc.

SKB had concluded that their models used for pre-construction evaluation had been confirmed, as had those for water flow etc. In general they spoke with great confidence of the results of the evaluation and had concluded that little further generic work was needed: future work should be site specific.

The overall impression was of a very large, well engineered facility where a full simulation of a repository, including materials handling problems etc, was underway. Like the Canister Laboratory, this facility was less a laboratory along the lines of, for example, Whiteshell, than a prototype disposal facility.

Central Interim Storage Facility for Spent Nuclear Fuel (CLAB)

Dr Per Grahn, Director of CLAB described the facility. Started in 1985, it had a capacity for 5,000 tonnes of spent fuel: there were plans to increase this by another 3,000 tonnes. They took about 80 casks per year and spent Kr75 million per annum. The construction costs in 1988 were Kr1.7 billion.

Our visit followed the process route starting with the receiving area where the dry fuel containers were unloaded into tanks at the surface. The system was designed to ensure that there was no cross-contamination between equipment handling the incoming casks and those on their way to storage: and defective casks could be easily isolated. Casks were then transported via a water filled lift to one of five main storage vaults underground. These were built on supports just above the bedrock as part of the earthquake protection measures. As with everything we had seen at SKB, the housekeeping and quality of the engineering was impeccable and all the facilities very modern.

Notes of visit to France
20-23 October 1998

Members present: Lord Tombs (Chairman), Lord Craig of Radley, Lord Howie of Troon, Baroness Platt of Writtle (Paris only) and the Earl of Cranbrook (Cherbourg only), accompanied by the Clerk.

Summary

The Committee visited the Cogema and Andra sites at Cap de la Hague on the Cotentin peninsula, followed by meetings with Government and with OECD officials in Paris. There was a marked contrast between the views expressed at the Industry Ministry (and Cogema) with those at the Environment Department. These must be resolved before the French disposal program can proceed in line with the '91 Law' but nobody we spoke to thought the disagreement would be resolved quickly.

Cap la Hague

Cogema

The Committee was welcomed by Monsieur Xavier Rincel, Chargé de Mission auprès de la Branch Combustibles et Recyclage, who provided a brief overview of the La Hague site. It is large, approximately 3 x 1 km, with two main reprocessing plants. The earlier, UP2 is used primarily to reprocess French spent fuel and the other,UP3, processes foreign material. The latter has contracts until the year 2010. M Rincel described the fuel cycle, emphasising the benefits of reprocessing as a waste management service. At La Hague they did not produce MOX which was fabricated at Pierrelatte. Our discussion concentrated on the more modern UP3 plant. This came into operation in 1989 with a nominal capacity of 800 tonnes.

Mme Veronique Decobert, Directeur Sureté Qualité, made a presentation on Cogema's environmental and health physics programmes. which concentrated on environmental pathways to man. It regarded "technical feasibility" and the "environmental impact" as the key factors of the OSPAR agreement.

EdF use MOX in 28 of their plants but only in the 900 MW reactors - not the later 1300 MW units. If used at 30% we were told this would create a balance between plutonium produced and plutonium burnt. If exports to Germany are increased there would be a net reduction in plutonium stocks and, in any case, the Melox plant could transfer all current plutonium production into MOX for French reactors. Cogema acknowledged that EdF had assumed that uranium would be cheaper than reprocessed MOX and that there were some economic doubts about reprocessing MOX, but EdF had "14 years to decide" the route for spent MOX fuel. There were long term reprocessing contracts with Germany, Japan, Switzerland and Belgium, but the current throughput of 1600 tonnes would be reduced by 30 % in three years' time. However at the end of current contracts all capital costs will have been met.

We were shown around the plant, following the process from the arrival of the casks, opening underwater, storage, sheering, vitrification and store. In appearance the plant was very similar to BNFL's

THORP operation and most of the site is under 13 years old.

Andra

We were welcomed by the Manager of the La Manche low-level waste facility, M Frank Duret and M Jacques Tamborini who provided an historical overview of the Parc de la Croix Blanch facility as well as a general outline of the French nuclear waste management programme.

Andra was created in 1979 as part of the Atomic Energy Commission. It handles research for waste management as well as design and construction of facilities. Ministerial responsibility is split between the departments of Health, Industry and Environment which means that in the end the Prime Minister has to make the decisions, particularly when Industry and Environment are in disagreement.

M Tamborini described the "91 law" which had established a clear-cut framework for radioactive waste management. The law recognised deep geological disposal as the only safe method but public acceptance of an RCF had not been achieved because local acceptance was not forthcoming. The French government helped communities decide by offering 5 million francs per year to those that volunteered. If work started a total of 60 million francs per annum was available until the year 2006.

Work would need to commence at more than one site so that there could be a fallback if one was found unsuitable. The current philosophy was to maintain retrievability of waste for a period. M Tamborini acknowledged that there was a risk that the French government's decision would be delayed.

Paris

French Government: Ministry of the Economy, Finances and Industry

M Antoine Guéroult, Adjoint au Directeur Général de I'Energie et des Matières Premières, observed that the total stock of French plutonium was increasing. It was more difficult to return waste to overseas contractors and France was not burning plutonium fast enough, although it might reach equilibrium if all 28 reactors capable of using MOX were fully utilised. On the economics he referred to an OECD study which indicated the closed fuel cycle and disposal were very comparable. But with the plant built and the plutonium in existence from this point on, he said, it made sense to use MOX.

French Government: Ministry for Territorial Development and the Environment

Madame Dominique Voynet, Minister for Territorial Development and the Environment told us that she regarded plutonium as a waste. She said that the economics of MOX were far from convincing and that she had asked the Prime Minister for an economic analysis. She said she was suggesting to the Prime Minister that plutonium be declared a waste now.

The Minister outlined progress with the 91 Law saying it was based on a comparison of surface storage with deep disposal, but an intermediate proposal, near surface storage where the waste was easy to recover but protected against intervention, was a more sensible alternative. She acknowledged that transmutation would not be available for decades and would be at considerable cost. The construction of a rock laboratory created political and local tensions and would also be extremely costly she said.

The Minister developed an argument for reversibility based on ethical and political grounds, stating that a short time ago the scientists were 100% confident that a repository should be closed, whereas now they were speaking with less certainty. Similarly it was premature to rule out any new technologies or even reuse. She acknowledged her views were not shared by the majority of the present Government but, irrespective of her personal position on the future of the nuclear industry, she was confident that governments should examine the costs of the disposal options.

When expressing her views on energy use, CO_2 etc, the Minister stated that nobody envisaged stopping the nuclear industry in a day but diversity of supply, better control of use etc, together with unsound economics, did not suggest an expanding nuclear programme. However there was no hurry to make a premature decision over the disposal of waste. France should take time to look at all the options and initiate a democratic debate about possible solutions. The only proposal which led to an irreversible decision was to go for direct geological disposal. There was no need for this decision to be taken now, indeed it was technically unsound to do so. Techniques for reversible storage should be evaluated for the next ten to twenty years.

The Minister developed the theme that research into storage technology was expensive and therefore should be shared at a European level with each country working in parallel on various techniques. Rock laboratories were expensive and should not be duplicated. Mme Voynet also discussed the difficulties over public perception if France developed a rock laboratory.

OECD Nuclear Energy Agency

Señor Luis Echavarri, the Director-General of the NEA, introduced his team: Dr Makoto Takahashi, the Deputy Director responsible for safety; Dr Hans Riotte the German Head of Radiation Protection,; and Dr Claudio Pescatore the Divisional Head of Radiation Protection. Each for their part outlined the organisation and work programme from their perspective. They provided us with comprehensive documentation reviewing the position on waste disposal in OECD member countries. Hans Riotte summed it up by stating that there are no inseparable technical or geological constraints. It should be possible for any country to find a suitable disposal site.

The data showed that whilst many countries had found disposal sites for very low level waste, none had done so for high level waste although there were many investigations under-way. Dr Riotte emphasised the different regulatory regimes across OECD countries, each with different views on acceptability and different administrative systems.

Dr Claudio Pescatore made a presentation on geological disposal. He acknowledged that there had been repeated statements by safety authorities that deep disposal could provide adequate safety but the public remained unconvinced. Techniques such as partitioning and transmutation might become part of waste management practices in future but they would not be an alternative to disposal. He described a phased procedure leading to disposal, starting with an extended interim store with reversible placement. This would enable a demonstration phase to be completed before confidence was gained to seal the repository.

Dr Pescatore commented on extrapolation into the future based on limited experience, observed that future generations will be able to apply their own technical solutions but must be presented with the best we can offer, and that a progressive approach to disposal enabled corrections to be made if unexpected events occurred. He said an OECD group was working on the "confidence aspects": the ethical, economic and political issues related to disposal. It was organisational structures more than technical issues that inhibited progress.

Select Committee on Science and Technology Third Report

APPENDIX 5

Glossary of Terms and Acronyms

" 10^{-6}"	Often proposed as the standard design criterion for a nuclear waste repository: the risk of death to an individual in the critical group of one in one million per year (ie 10^{-6}). On the same basis as the criterion was derived the risk from natural background radiation is about one in ten thousand.
ACSNI	Advisory Committee on the Safety of Nuclear Installations (renamed NuSAC in July 1997).
AECL	Atomic Energy of Canada Limited.
AGR	Advanced Gas cooled Reactor.
Anaerobic	In the absence of free oxygen.
Becquerel	The standard unit of radioactivity , equal to one nuclear disintegration per second. A becquerel (Bq) is a very small unit and when discussing radioactive waste the term terabecquerel is often more appropriate: one terabecquerel (TBq) = 10^{12} Bq; ie a million million disintegrations per second.
BGS	British Geological Survey.
BNFL	British Nuclear Fuels plc (previously British Nuclear Fuels Ltd).
CANDU	Canadian Deuterium Uranium water-cooled reactor type. The fuel consists of un-enriched ceramic uranium oxide pellets within zirconium alloy tubes.
Cmnd	Government command paper.
COLA	Consortium of Opposing Local Authorities.
Committed waste	Waste which cannot be avoided. It will be created even if the entire nuclear industry were to cease operation immediately: the waste either already exists or will result from the decommissioning of existing installations.
CORE	Cumbrians Opposed to a Radioactive Environment.
Critical group	The group of people who, on basis of age, living habits and place of residence, receive the highest radiation dose. (This may be an existing or hypothetical group.)
Decommissioning	The term decommissioning is used in a generic sense to cover all of the procedures undertaken once a nuclear installation has ceased operating. Decommissioning therefore covers processes such as defuelling reactors, cleaning and making safe an installation (which could include a long period of safe storage on site), dismantling, removal work and waste conditioning prior to storage or disposal.
Depleted uranium	Uranium consisting predominantly of non-fissile uranium.
DETR	Department of the Environment Transport and Regions.
DTI	Department of Trade and Industry.
EURATOM	European Atomic Energy Community.
Fissile	Refers to a radionuclide which can break into two large fragments accompanied by the release of free neutrons and large amounts of energy. A few man-made radionuclides are so unstable that they fission spontaneously; others can do so if the nucleus captures a neutron.
Fission products	The atomic fragments resulting from nuclear fission. For instance, the two large atomic fragments produced by the fission of uranium-235 might be isotopes of tin and

	molybdenum, which themselves are likely to be highly radioactive.
GRA	Guidance on Requirements for Authorisation (for disposal facilities on land for LLW and ILW). A document outlining safety standards for disposal.
Half life	The time required for half of the atoms in a sample to decay or transform. For example: the radionuclide krypton-85 has a half-life of 3,934.4 days and decays to the stable isotope rubidium-85 by emitting a beta particle; after one period of 3,934.4 days, 50 per cent of the initial krypton-85 atoms in a sample will have become rubidium-85; after ten half lives (107 years, 9½ months) the sample will contain just 0.1 per cent krypton-85, and 99.9 per cent rubidium-85.
HLW	High Level radioactive Waste. Highly active heat generating waste that normally continues to generate heat for several centuries. A high level of shielding and heat dissipation is required during handling, transportation, and storage (and disposal). Its thermal power is above 2 kW per m^3. It may take many thousands, or millions, of years for the radioactivity of HLW to decay to background levels.
HSE	Health and Safety Executive.
IAEA	International Atomic Energy Agency.
ILW	Intermediate Level radioactive Waste. Waste in which radioactivity levels exceed the upper boundaries for LLW. Some of it requires shielding. Heat generation usually less than 2kW per m^3 but may require provision for heat dissipation during storage (or disposal).
Intergenerational equity	The concept that future generations should not have to bear the costs and consequences of actions which were of benefit mainly to present and previous generations.
LLW	Low Level radioactive Waste. Radioactive materials other than those suitable for disposal with ordinary refuse, but containing less than 4 $x10^9$ Bq per tonne of alpha activity or less than 12 x 10^9 Bq per tonne of beta/gamma activity. Does not require shielding during normal handling and transportation.
Magnox	Reactor type using uranium metal fuel rods enclosed in a cladding of magnesium alloy.
MoD	Ministry of Defence.
MOX	Mixed Oxide Fuel (a mixture of plutonium oxide and uranium oxides).
MTR	Materials Testing Reactor.
NCNI	National Campaign for the Nuclear Industry.
NEA	OECD Nuclear Energy Agency.
NERC	Natural Environment Research Council.
NGO	Non Governmental Organisation.
NII	Nuclear Installations Inspectorate (part of the HSE).
NIMBY	Not In My Back Yard. Referring to objections to activities nearby, e.g. planned nuclear installations, or motorways.
Nirex	United Kingdom Nuclear Industry Radioactive Waste Management Executive.
NRPB	National Radiological Protection Board.
NSC	National Steering Council for Nuclear Free Local Authorities.
NuSAC	Nuclear Safety Advisory Committee (originally ACSNI).
OECD	Organisation for Economic Co-operation and Development.
Palaeoclimatic	Concerned with the climate in the geological past.
Partitioning	Specifically the separation of certain radionuclides from other wastes so that they may be subjected to transmutation.

Probabilistic assessment	In the case of a repository, a safety assessment that takes into account the probabilities and consequences of events and processes that could lead to radionuclide releases, or influence release rates, and also takes account of uncertainties in estimating probabilities and consequences.
POST	Parliamentary Office of Science and Technology.
PWR	Pressurised Water Reactor.
R&D	Research and Development.
Radionuclide	Any nuclide (isotope of an element) which exhibits radioactivity (ie can undergo spontaneous disintegration, releasing an alpha-particle, a beta-particle or a gamma-ray).
RCEP	Royal Commission on Environmental Pollution.
RCF	Rock Characterisation Facility (specifically the one planned in Cumbria).
RWMAC	Radioactive Waste Management Advisory Committee.
RWPG	Radioactive Waste Policy Group (in the DETR).
SAP	Safety Assessment Principles (for nuclear plants).
SEPA	Scottish Environment Protection Agency.
Sievert	A measure of radiation dose which takes into account the type of radiation involved, the energy deposited in the tissues irradiated, and the sensitivity of the different body tissues to radiation. Typically, doses are expressed in terms of micro sieverts (µSv). 1 sievert = 1 million µSv. A dose of around 6.5 Sv, delivered over a few minutes or hours, will lead to death from acute radiation sickness within a few weeks. The annual average dose to an individual in the United Kingdom is 2,200 µSv from natural radiation and 400 µSv from man-made radiation, (of which 370 µSv is from medical uses of radiation and radioactive materials).
SKB	Svensk Kärnbränslehantering AB (Swedish nuclear fuel and waste management company).
Subduction zone	Area of the Earth's surface where one tectonic plate is over-ridden by another: typically an oceanic plate will subduct beneath a continental plate. It has been suggested that depositing nuclear waste in or on a plate that is being subducted will lead to it being transported into the mantle and thus out of the biosphere.
Terabecquerel	10^{12} Becquerels.
THORP	Thermal Oxide Reprocessing Plant (at Sellafield). Oxide fuel is used in AGRs, PWRs and other light water reactors.
Transmutation	Process by which radionuclides are bombarded with neutrons (either in a reactor or a particle accelerator) and are converted into shorter-lived or stable nuclides.
UKAEA	United Kingdom Atomic Energy Authority, now known only by its acronym.
URL	Underground Research Laboratory.
Vitrification	The process by which radioactive waste (typically HLW) is immobilised in borosilicate glass.
VLLW	Very Low Level radioactive Waste. Formally defined as material in which each 0.1 m^3 contains less than 4×10^5 Bq of beta/gamma activity or single items which contain less than 4×10^4 Bq of beta/gamma activity. This waste can be disposed of at landfill sites without special treatment.
WIPP	Waste Isolation Pilot Plant. An underground waste repository built in salt deposits in New Mexico US for military nuclear waste.