CORWM

Committee on Radioactive Waste Management

Managing our Radioactive Waste Safely

CoRWM's recommendations to Government

CoRWM Doc 700

July 2006

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ANNEXES

Introduction by the Chair

The Committee on Radioactive Waste Management was asked by Government in 2003 to make recommendations for the long-term management of the UK's higher activity wastes that would both protect the public and the environment, and inspire public confidence. To do this, we have combined a technical assessment of options with ethical considerations, examination of overseas experience and a wide-ranging programme of engagement both with the public and with interested parties (stakeholders). I am happy to present our recommendations in the pages that follow. Chapter 14 contains our main recommendations and brief rationales for each.

This integrated package of recommendations deals centrally with specific management options for radioactive wastes but they are also framed more broadly. Government, in setting the Committee's terms of reference, also suggested that we might also want to offer advice on implementation issues and we have placed our recommendations on options within a proposed implementation process. Reports on implementation and on the inventory of wastes are also attached to this report.

It is impossible to acknowledge all the many individuals and organisations that have helped CoRWM to reach its conclusions. But I do especially want to thank both our secretariat and our programme managers (AMEC NNC for most of the two and a half years) without whom our very large task would have proved impossible in the time we had to complete our work.

The Committee believes that our recommendations form a sound basis for the further development of radioactive waste management policy in the UK, and urges Government to build on the momentum we have helped establish.

Gordon MacKerron
31 July 2006

Overview: Radioactive waste - a new approach

For over three decades, efforts to find solutions to the problem of long-term radioactive waste management in the UK have failed. Government initiated a fundamental review of policy and appointed the Committee on Radioactive Waste Management (CoRWM) to take this forward. CoRWM has adopted an innovative approach, based on engagement with the public and stakeholders, expert knowledge and reflection on ethical issues. Consideration of these inputs has led to a set of interdependent proposals which recommend: (1) geological disposal as the end state; (2) the vital role of interim storage; and (3) a new approach to implementation, based on the willingness of local communities to participate, partnership and enhanced well-being. The proposals form a basis for Government to act upon without delay.

2. Ever since the Flowers Report three decades ago drew attention to the problem, the UK has sought but failed to find a long-term solution to the problem of managing its higher activity radioactive wastes. In part, the problem has been a technical one, the need to identify solutions which, in the words of the Flowers Report, could demonstrate 'beyond reasonable doubt that a method exists to ensure the safe containment of long-lived highly radioactive waste for the indefinite future'.[1] But radioactive waste is also a social problem. Its association with nuclear energy and weapons and the risks to health from radioactivity make the management of radioactive waste an issue of controversy and conflict. A solution to the problem must not only be technically achievable but also publicly acceptable. CoRWM's terms of reference (see Annex 1) recognise this in specifying the need for management options that both protect people and the environment and inspire public confidence. This Report brings together both technical and social considerations, in setting out the best way forward for the management of radioactive wastes in decades to come.

3. The problem of radioactive waste must be understood in terms of a changing social and political context. From the later 1940s until the early 1970s radioactive waste did not constitute a political problem. The focus was on the development of the nuclear industry and the weapons programme; wastes were either dumped at sea (first near the Channel Islands, later in the north Atlantic) or accumulated in stores at nuclear sites, notably Sellafield and Dounreay. From the mid 1970s until the early 1990s, the international nuclear industry experienced a series of setbacks in terms of high costs and technological problems. These included accidents at Three Mile Island and later at Chernobyl, growing concerns about radioactive emissions and, in the UK, conflicts over proposals for reprocessing and proposed locations for radioactive waste facilities. The links to weapons, and the dangers of proliferation, further added to a decline in confidence and a lack of trust in the nuclear industry. During this period, every initiative to find a way forward to manage radioactive waste foundered in the wake of opposition and protest. First, the drilling programme to assess the geological suitability of sites for high level waste disposal faced local protests and was abandoned. Then, sea dumping of wastes was suspended in the face of combined action by trades unions, Greenpeace and international protests. Next came attempts to find suitable sites in eastern England for the disposal on land of intermediate and low level wastes which were effectively countered by coalitions of local government and citizen protest movements.

4. These initiatives tried to impose technical solutions but failed to respond to the need for public acceptability. In an effort to find a solution that would be technically suitable, but also achieve local public support, the Nuclear Industry Radioactive Waste Management Executive (Nirex) identified Sellafield and

Dounreay (later withdrawn) as potential sites for the deep disposal of intermediate and low level wastes. After an extensive borehole drilling programme and a lengthy Public Inquiry, the proposal for an underground laboratory (Rock Characterisation Facility, RCF) at Sellafield was rejected in 1997. The series of reversals culminating at Sellafield had left the UK without any options for the long-term management of its solid intermediate and high level radioactive wastes.

5. The rejection of the Sellafield RCF, though a setback at the time, proved also to be an opportunity. It offered a fresh start. Moreover, the social and political context was becoming more favourable to finding an acceptable solution. By the late 1990s conflicts over reprocessing and radioactive waste were receding, memories of major accidents were fading and nuclear energy was in retreat. In such circumstances, it seemed possible that both pro- and anti-nuclear interests might work together to find the best solution to deal with the hitherto intractable problem of radioactive waste. Given the nature of the problem in the UK, and the history of conflict over earlier proposals, this was a moment to undertake a complete review of the issue. In the absence of any ongoing initiatives, it was possible, and necessary, to go back to the beginning, to undertake a fundamental policy review for the management of radioactive wastes.

6. The House of Lords Select Committee on Science and Technology addressed the issue of radioactive waste in its report in 1999.[2] It recognised that 'openness and transparency in decision making are necessary in order to gain public trust' and that mechanisms to include the public in decision making would be necessary. The report proposed setting up a Nuclear Waste Commission with the initial task of consulting on a comprehensive policy. The Radioactive Waste Management Advisory Committee (RWMAC) in a series of reports [3] set out the key guiding principles for the process of developing policy. These included early involvement of the public, adequate time to take decisions, openness and transparency, and a deliberative, accessible approach to decision making. RWMAC also advocated a staged process managed by an 'oversight body'.

7. These and other similar proposals were embraced in the Government's Managing Radioactive Waste Safely consultation paper published in 2001.[4] The aim was to develop and implement a policy which 'inspires public support and confidence'. The paper went on, 'to do that, we have to demonstrate that all options are considered; that choices between them are made in a clear and logical way; that people's values and concerns are fully reflected in this process; and that information we provide is clear, accurate, unbiased and complete'. On the basis of the consultation, the Government proposed that an 'independent and authoritative' committee be set up with terms of reference 'to oversee a review of options for managing solid radioactive wastes in the UK and to recommend the option, or combination of options, that can provide a long-term solution providing protection for people and the environment'. Its task was to 'inspire public confidence' by engaging with the public, and applying ethical principles as well as the best science and technology to decision making. CoRWM was appointed to undertake this task and began its work in November 2003.

8. CoRWM is an advisory body with members appointed with a range of expertise able to offer scientific, social, economic, environmental and public perspectives on the issue of radioactive wastes. It is a Committee that has brought a diversity of viewpoints, experience and knowledge to its work. CoRWM was presented with a unique opportunity to develop a process for selecting options and to consider ways forward for implementing its proposals. Most countries have programmes for identifying sites for radioactive waste disposal that include forms of public participation. These programmes have experienced various degrees of success, with Finland and Sweden at the present time furthest ahead in terms of siting repositories for the geological disposal of civil wastes. The UK is the only country which has used an extensive programme of public and stakeholder engagement in

going back to the beginning and has undertaken a thorough analysis of all options for waste management. After the Sellafield RCF decision, the UK was lagging behind other countries in its policy for radioactive waste management. If the Government accepts these recommendations, the UK can point to an innovative and radical policy process that, in certain respects, is well in advance of those being pursued elsewhere. In CoRWM's view, it provides a way forward that is both achievable and acceptable.

9. At the technical level, the UK's radioactive waste problem has distinctive characteristics. It has substantial volumes of so-called 'legacy' wastes arising from the weapons programme, from its various experimental reactor programmes, from nuclear power plants and from the reprocessing of their spent fuel. The waste streams are complex and some of the earlier wastes were managed to lower standards than today's, thereby necessitating a major clean-up effort currently being undertaken by the Nuclear Decommissioning Authority (NDA). The lower level wastes are disposed of, for example at the shallow low level waste repository near Drigg in Cumbria. It is the higher level wastes that are the subject of this Report. They comprise wastes already in store and those which will arise from existing nuclear activities in the future. These committed wastes constitute a total of approximately 478,000 cubic metres (a volume five times that of London's Royal Albert Hall) and an activity of 78 million terabequerels.* The volume and complexity of the UK's radioactive waste inventory presents a considerable technical challenge that must be met to ensure safe management over the long-term. CoRWM has, following its terms of reference, also examined the way in which plutonium, uranium and spent fuel should be managed if in future they are treated as wastes.

10. CoRWM's approach embodied the following elements:

i. **Ethics**. At the start of its work CoRWM developed a number of key Guiding Principles. They have been actively pursued in all aspects of the Committee's work. The Principles reflect the values which the Committee believes are integral to the development of a successful waste management policy. In particular the values of equity (fairness) and sustainability have played a vital role in the assessment of options. CoRWM also paid explicit attention to the way in which ethics play an integral part in deciding on what to do with radioactive waste. It paid particular attention to the issue of fairness between generations and to the different ways in which the principle of intergenerational equity can be interpreted as well as to the practical applications of any given interpretation. Ethical perspectives may be in conflict. In reaching its recommendations, CoRWM had to achieve a consensus which could incorporate the different ethical positions held by its members. One of the strengths of CoRWM's recommendations is that they are founded on ethical principles.

ii. **Participation**. CoRWM placed a very high value on the need to engage with stakeholders and citizens. There were four main phases of public and stakeholder engagement (PSE) designed to involve participants in continuing contribution to key decisions. Various techniques were used including stakeholder round-table discussions, Citizens' Panels, a National Stakeholder Forum and open meetings. Wider audiences were reached, including young people through an in-depth Schools Project involving 15 schools and 1305 students in Bedfordshire, through a widely circulated Discussion Guide and through some 700 website and written responses. All contributions were recorded and comprised a significant input to CoRWM's decisions. Members of the public were also able to participate through attendance at CoRWM's

* Radioactivity is measured as the rate at which atoms disintegrate. One Becquerel (Bq) is equal to one disintegration per second. One terabecquerel is a million million becquerel.

plenary meetings, which included public question and answer sessions, and through written and web-based correspondence. CoRWM's PSE programme is probably the most wide-ranging, informative and influential effort so far undertaken in the UK in public decision making. It has proved an integral element in the CoRWM process and provides the basis on which the Committee can claim it has laid the foundation for inspiring public confidence in its recommendations, especially as the response to the Committee's draft recommendations was supportive from nearly all respondents.

iii. **Use of expert knowledge**. If the Committee's recommendations are to offer protection to people and the environment, they need to be based on the best available scientific and technical knowledge. CoRWM engaged with the scientific community in a variety of ways. For example, it used expert knowledge in a specific context in short-listing options; it deployed much more intensive application of scientific knowledge to the detailed assessment of short-listed options in assessing option performance within the framework of formal Multi-Criteria Decision Analysis (MCDA); and it used broader scientific assessments to examine the critical question of confidence in the long-term safety of geological disposal.

iv. **Deliberation.** In line with its terms of reference, the Committee adopted a deliberative approach to its work from the outset. Deliberation enables knowledge, values and ideas to be explored and discussed openly among participants. Starting from multiple and sometimes conflicting perspectives, it helps enable a rational weighing of evidence. A deliberative process should be inclusive and facilitate consensus building through expressing and integrating divergent viewpoints. Deliberation was an integral part of CoRWM's decision making process. The Committee deliberated in public in deciding the shortlist of options, in assessing the options both in formal and holistic ways and in coming to its overall conclusions on the best options for managing wastes. Deliberation was a major feature of CoRWM's engagement with the public and stakeholders in decision making. The report on Deliberative Democracy and Decision Making for Radioactive Waste explains what deliberative approaches are and how they can be translated into decision making.[5] CoRWM's deliberative approach has helped to ensure that its conclusions are as balanced, fair and comprehensive as possible.

v. **Democratic.** Taken together, deliberation and participation have enhanced the democratic nature of CoRWM's decision making. The process was democratic in several respects. First, it encouraged equality of exchange among participants. Second, it tried to reflect all the relevant viewpoints and values. Third, it enabled decisions to be reached based on a shared understanding. Deliberative approaches to participation provided a basis for informed judgements and decisions. Thus, the PSE process informed CoRWM's recommendations which, in turn, are presented to Government for its decision. While democratic deliberation informs, representative democracy ultimately decides. But, CoRWM's process offers a far more informed basis for political decisions on the management of radioactive waste than has existed previously.

vi. **Integration**. CoRWM's decision making has been informed by different forms of knowledge. Scientific knowledge was used at several different points in the process, for example in the MCDA where panels of experts discussed criteria and scoring for option assessment. There was extensive consultation with the nuclear industry, regulators and advisory bodies. Overseas experience was drawn on to identify potential approaches both to option assessment and implementation. Stakeholders and the public provided various forms of knowledge. An holistic assessment enabled a more discursive and intuitive approach where ethical, scientific and public forms of knowledge could be brought together in reaching conclusions. Overall, it was CoRWM's task to integrate the variety of knowledge streams in making its final recommendations. The recommendations, then, are not simply an expression of expert knowledge and judgement. They reflect the combined knowledge developed by the Committee. It was gratifying to discover that different forms of knowledge were, on the whole, not in conflict but complementary, providing mutually reinforcing contributions to the decisions that were reached.

vii. **Implementable**. CoRWM's main task was to identify the best option or combination of options for managing higher activity radioactive waste in the long-term. But the Committee was also invited to consider siting issues. This does not mean identifying potential sites, rather, as the terms of reference put it, generic issues including, 'whether local communities should have a veto or be encouraged to volunteer, and whether they should be offered incentives'. CoRWM has not adopted the approach of incentives to volunteer and compensation for taking on burdens on behalf of society. The approach is based on the enhancement of the well-being of communities who are willing to participate in the management of radioactive waste. This may be achieved in various ways. One is through the development of Involvement Packages to enable communities to participate and Community Packages that provide the resources to support both the short and long term well-being of the community. Another way to ensure well-being is through a partnership approach whereby communities hosting radioactive waste facilities enjoy an open and equal relationship with the Implementing Body. In these ways, communities would have more control over decisions that affect their well-being, including whether to participate, how to make use of resources and the ability to influence the development of the project together with the right to withdraw from the partnership up to a pre-defined stage. Previous attempts at finding sites for radioactive waste facilities relied on the imposition of solutions from above. CoRWM's approach is quite different and rejects such imposition. The Committee considers its approach, supported by its PSE process, offers a radical but realistic way forward to successful implementation of its recommendations.

viii. **Interdependence**. CoRWM's proposals for the long-term management of radioactive waste form a carefully articulated and integrated set of recommendations which are interdependent and which the Committee believes can only be successful if adopted as a package. In this sense CoRWM has gone beyond the narrow confines of its remit. It is not simply offering the best option or combination of options in a narrow and technical sense. Rather, the proposals set out the constraints and uncertainties, technical and social, that will influence the achievement of the recommendations. In reaching its proposals, CoRWM has analysed and taken account of PSE, scientific and other inputs to show a future pathway. It presents a well-researched political and social analysis of the possibilities. The recommendations recognise that geological disposal is the right end-point for all, or almost all, the wastes in the CoRWM inventory but also recognise the significant role that must be played by storage both as an interim solution on the route to disposal as well as a contingency in the event of any interruption in the progress towards the end-point. In carrying forward the recommendations, a staged process supervised by an independent Overseeing Body is recommended. Overall, CoRWM's proposals offer Government a way of getting from the present to the future that, if followed, is most likely to prove successful.

11. The results of these processes are a set of recommendations. These are presented, with their main rationales, in Chapter 14 and reproduced here at paragraph 21.

12. The management of radioactive wastes is a problem that extends into the far future. Over such long time-scales, dealing with uncertainties becomes a central issue. The problem that faced CoRWM may be conceived as one of managing the waste in the face of uncertainties. In reaching its recommendations, CoRWM, in conjunction with experts and stakeholders, has had to assess the importance of different forms of uncertainty at different times in the future. This assessment has focussed on the fundamental choice that has to be made between options relating to continuing storage of wastes and options which favour geological disposal.

13. One way of understanding the issues is to consider the contrast between the time-scales appropriate to what may be called geoscientific time and those relating to cultural time. Geoscientific time-scales are relevant to geological disposal options and are concerned with the safety of repositories over periods of hundreds of thousands of years. The focus of attention here is on the uncertainties associated with engineered and geological barriers and hence on the stability and integrity of engineered and geological containment systems. The question for CoRWM was, 'is scientific knowledge about the safety of containment systems in the far future sufficiently credible to enable commitment to geological disposal now?' This is both a scientific and an ethical question. The scientific aspect concerns what we can do in the knowledge that the level of uncertainty, and hence the predictability of change, increases with time. 'At some time, uncertainty will be so great that precise, quantitative predictions will become meaningless'. [6] However it is also the case that over hundreds of thousands of years radioactive decay reduces potential hazards, eventually to insignificant levels. The ethical question concerns the way in which society now should discharge its responsibilities to the far future. Members generally accepted the ethical case for treating all future generations equally, but disagreed on the implications of this in terms of action. One view is that responsibility for the future should not diminish over time, therefore we should avoid actions that might impose risks on generations in the far future. The other view is that since we cannot exercise control over the far future we should pay more attention to the impacts of our actions in the near future.

14. The dilemma of whether to take action now (start the process of disposal, recognising that flexibility will gradually decline) or avoid making a final decision (by continuing interim storage allowing flexibility and later choices but also imposing burdens) is also present in the context of cultural time, the time-scale of human perception and concern. By comparison with geoscientific time-scales, cultural time-scales are very short. Indeed, it is often asserted [7] that the period of human concern about the future extends no further than one or two generations, perhaps no more than a hundred years or so. Human perception tends to be conditioned by historical time-scales, in other words we tend to look as far forward as we can look back, a time-scale measured in hundreds of years. Over such relatively short time-scales (in terms of radioactive waste) it is the uncertainty surrounding the stability and survival of institutions that is of greatest concern. Few institutions have survived for more than a few hundred years and most have life-spans measured in decades rather than centuries. The issue of institutional control has a bearing on the time-scale for storage options and how long retrievable options (storage or phased disposal) might be continued to allow future generations to have a say in decision making. Again there are scientific (including social scientific) as well as ethical aspects to the question. The scientific aspect concerns the survival of stores and institutions that can maintain them. Ethically, the problem is whether, in the interests of providing flexibility for future generations to make their own decisions on how to manage wastes, it is right to pass on burdens of cost and risk.

15. The trade-offs between flexibility and burden are at the heart of the choice among options. They emerged as one of the major discriminating issues in the MCDA, were the focus of the ethical debates over intergenerational equity and were a constant theme throughout the PSE process. In reaching its own conclusions

CoRWM concluded that, within the context of present knowledge, it had sufficient confidence in geological disposal as the best method for long-term management, and the relevant regulators believe that they could, in principle, accept a long-term safety case. But CoRWM's recommendations needed to take account of the uncertainties surrounding disposal. Therefore, the recommendations indicate the need for continuing research on geological disposal and storage to reduce uncertainties and a commitment to leaving open - until repository closure - the possibility of alternative management options becoming available. These and other caveats resulted in a set of interconnected proposals leading to geological disposal as the end-point.

16. Having opted for geological disposal as the recommended end-point, the Committee was then faced with the issue of how soon the option could be implemented, and when a repository should be closed. This gave rise to considerable debate among experts, stakeholders and within CoRWM itself. In the first place, the Committee recognised that the disposal option could not be implemented for several decades. It concluded that there were social and ethical concerns within UK society about the disposal option that would need to be resolved as part of the implementation process. This is quite aside from the fact that the process of implementation, requiring willing communities, the setting up of partnerships, as well as the development and engineering of the repository itself, would take a considerable time. All this would have a bearing on the form of disposal ultimately chosen. For CoRWM, the critical issue was whether it believed that the repository should start to be closed as soon as practicable (the 'early closure' option) or whether it should be left open for future generations to decide when to close it (the 'phased disposal' option). The key issues are summarised here.

17. Among the arguments in favour of 'early' closure (in practice at least a century from now), assuming sufficient confidence in the long-term safety of the concept, are:

- It minimises the burdens of cost effort and worker dose transferred to future generations.
- It recognises that future generations may lack the skills or motivation to deal with the wastes.
- It places less reliance on maintaining institutional controls.
- It provides greater safety in the near term, which is what concerns people most.
- It provides greater security from terrorist attacks and the problem of nuclear proliferation.
- Keeping a repository open even for a few centuries will not add materially to existing knowledge of its probable long-term behaviour.

The arguments that support early closure also support early backfilling vault by vault as the waste is emplaced.

18. The case for leaving the repository open after it is filled with waste (for up to 300 years or possibly more) rests on the following arguments:

- It provides flexibility for future generations to take decisions.

- It allows for the lack of trust and confidence in the long-term safety case for disposal.
- It enables future generations to have access to a potential resource.
- It leaves open the possibility of alternative or improved methods for management of wastes.
- It seeks to maintain flexibility whilst making progress in reducing the burden.

19. After considerable debate, CoRWM has reached the unanimous conclusion that early closure is a preferable course of action. Its reasoning includes the points made above but also reflects the fact that early closure will not be achieved until at least a century from now. This, in the Committee's view, provides sufficient flexibility for further research to be undertaken to achieve public confidence and approval and to provide for key decisions to be taken in future.

20. Nonetheless, CoRWM recognises that many stakeholders and citizens have expressed strong support for phased geological disposal, and did not want the Committee to make a prescriptive recommendation about forms of geological disposal. Some members therefore consider that potential host communities should be given the opportunity to scrutinise the pros and cons of different forms of geological disposal, taking into account the views of CoRWM and those with regulatory responsibility. While recognising that Government and regulators will need to be involved, these CoRWM members think that potential host communities should have a considerable influence on final decisions about whether to design a repository for early or delayed closure. Other members consider the case against phased geological disposal to be sufficiently strong that CoRWM should recommend an early closure repository design. While these members support the idea that potential host communities should be able to influence repository design, they do not think that this influence should extend to the possibility of designing a repository to stay open for up to 300 years or more. As a result the Committee has not reached agreement in this area and accepts that this issue will continue to be a matter for public debate.

21. The role of storage as an integral element in the recommendations is extremely important. Storage is the only available option in the short and even medium term and the NDA is responsible for the safe and secure management of the majority of existing stores. It has recently published its Strategy and is actively considering storage options, including the balance of advantage between local and more centralised versions of storage. The NDA is consulting widely on this and other issues. CoRWM's concern is with the development and location of stores that will form part of the interim management on the way to geological disposal. The Committee has explored a number of storage options and combinations including those with and without enhanced protection against terrorist attack, surface and underground, local and central. It has also looked at storage in relation to different waste streams. Among the factors affecting the location of new stores will be the desire to minimise transportation and double handling of wastes, the public acceptability of maintaining stores at existing locations or finding new locations and the vulnerability of sites to sea level rise and other factors. In principle, CoRWM's proposals for implementation, including willingness to participate and the development of partnerships supported by Community Packages, should apply to new central or major regional stores at new locations. The extent to which they should be applied to other new stores and changes to existing stores is a matter for further consideration.

22. The following are CoRWM's final recommendations

In the light of the views of consultees, CoRWM believes that its recommendations provide the basis for inspiring public and stakeholder confidence. We commend them to Government as an integrated package and urge progress without delay so that the momentum established by the CoRWM process is not lost. CoRWM considers that an open and transparent process is essential for successful implementation of these recommendations.

Recommendation 1: *Within the present state of knowledge, CoRWM considers geological disposal* to be the best available approach for the long-term management of all the material categorised as waste in the CoRWM inventory when compared with the risks associated with other methods of management. The aim should be to progress to disposal as soon as practicable, consistent with developing and maintaining public and stakeholder confidence.*

Recommendation 2: *A robust programme of interim storage must play an integral part in the long-term management strategy. The uncertainties surrounding the implementation of geological disposal, including social and ethical concerns, lead CoRWM to recommend a continued commitment to the safe and secure management of wastes that is robust against the risk of delay or failure in the repository programme. Due regard should be paid to:*

i. reviewing and ensuring security, particularly against terrorist attacks;

ii. ensuring the longevity of the stores themselves;

iii. prompt immobilisation of waste leading to passively safe waste forms;

iv. minimising the need for re-packaging of the wastes;

v. the implications for transport of wastes.

Recommendation 3: *CoRWM recommends a flexible and staged decision-making process to implement the overall strategy, which includes a set of decision points providing for a review of progress, with an opportunity for re-evaluation before proceeding to the next stage.*

Recommendation 4: *There should be a commitment to an intensified programme of research and development into the long-term safety of geological disposal aimed at reducing uncertainties at generic and site-specific levels, as well as into improved means for storing wastes in the longer term.*

Recommendation 5: *The commitment to ensuring flexibility in decision making should leave open the possibility that other long-term management options (for example, borehole disposal) could emerge as practical alternatives. Developments in alternative management options should be actively pursued through monitoring of and/or participation in national or international R&D programmes.*

Recommendation 6: *At the time of inviting host communities to participate in the implementation process, the inventory of material destined for disposal must be clearly defined. Any substantive increase to this inventory (for example creation of waste from a new programme of nuclear power stations, or receipt of waste from overseas) would require an additional step in the negotiation process with host communities to allow them to take a decision to accept or reject any additional waste.*

Recommendation 7: *If a decision is taken to manage any uranium, spent nuclear fuel and plutonium as wastes, they should be immobilised for secure storage followed by geological disposal.*

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* "Disposal" in the context of CoRWM's recommendations on geological disposal means the burial underground (200 – 1000m) of radioactive waste in a purpose built facility with no intention to retrieve the waste once the facility is closed.

Recommendation 8: *In determining what reactor decommissioning wastes should be consigned for geological disposal, due regard should be paid to considering other available and publicly acceptable management options, including those that may arise from the low level waste review.*

Recommendation 9: *There should be continuing public and stakeholder engagement, which will be essential to build trust and confidence in the proposed long-term management approach, including siting of facilities.*

Recommendation 10: *Community involvement in any proposals for the siting of long-term radioactive waste facilities should be based on the principle of volunteerism, that is, an expressed willingness to participate.*

Recommendation 11: *Willingness to participate should be supported by the provision of community packages that are designed both to facilitate participation in the short term and to ensure that a radioactive waste facility is acceptable to the host community in the long term. Participation should be based on the expectation that the well-being of the community will be enhanced.*

Recommendation 12: *Community involvement should be achieved through the development of a partnership approach, based on an open and equal relationship between potential host communities and those responsible for implementation.*

Recommendation 13: *Communities should have the right to withdraw from this process up to a pre-defined point.*

Recommendation 14: *In order to ensure the legitimacy of the process, key decisions should be ratified by the appropriate democratically elected body/bodies.*

Recommendation 15: *An independent body should be appointed to oversee the implementation process without delay.*

CoRWM takes no position on the desirability or otherwise of nuclear new build. We believe that future decisions on new build should be subject to their own assessment process, including consideration of waste. The public assessment process that should apply to any future new build proposals should build on the CoRWM process, and will need to consider a range of issues including the social, political and ethical issues of a deliberate decision to create new nuclear wastes.

23. Chapter 14 describes these recommendations in detail and the preceding chapters explain how CoRWM reached these conclusions.

24. CoRWM's work is part of a staged process initiated by Government in its 'Managing Radioactive Waste Safely' programme (MRWS). In its discussions with ministers, departments and the devolved administrations, CoRWM has been impressed by the sense of commitment within Government to finding a solution to the problem of radioactive waste. The Committee believes its recommendations are securely founded on scientific research, on broad public and stakeholder acceptance, on considerations of ethical and social issues and that they form a practicable, realistic and implementable set of proposals.

25. CoRWM's recommendations now need to be taken forward by Government. Given the past history of conflict and failure to achieve solutions, some expect hesitancy on the part of Government. Throughout the PSE programme there was scepticism as to whether Government would act on CoRWM's recommendations. At the same time, there was a very large measure of support for both CoRWM's approach and its recommendations and a strong expression that Government should capitalise

on the momentum that had been generated by taking action to implement the proposals.

26. Much will depend on being able to sustain the favourable political environment in which these recommendations have been developed. It must be emphasised that CoRWM's recommendations are directed to existing and committed waste arisings. CoRWM believes that its recommendations should not be seen as either a red or green light for nuclear new build. The main concern in the present context is that the proposals might be seized upon as providing a green light for new build. That is far from the case. New build wastes would extend the time-scales for implementation, possibly for very long but essentially unknowable future periods. Further, the political and ethical issues raised by the creation of more wastes are quite different from those relating to committed - and therefore, unavoidable - wastes. Should a new build programme be introduced, in CoRWM's view it would require a quite separate process to test and validate proposals for the management of the wastes arising. To that end, CoRWM has issued a statement on new build which is included after the recommendations in paragraph 21.

27. CoRWM's recommendations reflect a consensus achieved among its members which it believes lays the basis for wide-ranging public confidence. It considers that the Government can act with confidence in the knowledge that the proposals should be both politically feasible and publicly acceptable.

References

1 Royal Commission on Environmental Pollution, “Nuclear Power and the Environment”, Sixth Report of the Royal Commission on Environmental Pollution, Cm 6618, HMSO, 1976.

2 House of Lords (1999), “Management of Nuclear Waste”, Select Committee on Science and Technology, Session 1998-99, Third Report, HMSO, 1999.

3 Radioactive Waste Management Advisory Committee, (1999) "Advice to Ministers on the Establishment of Scientific Consensus on the Interpretation and Significance of the Results of Science Programmes into Radioactive Waste Disposal"; (2001) Advice to Ministers on the Process for Formulation of Future Policy for the Long Term Management of UK Solid Radioactive Waste, September; (2002) Response to the Government's Consultation Document: “Managing Radioactive Waste Safely”

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Chapter 1 Introduction – the radioactive waste problem

The problem is two-fold – technical and social. A large quantity of higher activity radioactive wastes exists now and significantly more will arise over the next 100 years or so. There is no currently agreed long-term management method for these wastes. There is also a high degree of historical distrust of the nuclear industry and those charged with developing waste management facilities, which has led to a breakdown of previous attempts to implement a policy. The key lesson from UK and international experience is that radioactive waste policies cannot be imposed as past 'decide–announce–defend' strategies. There has to be early public and stakeholder involvement in determining a policy that can inspire sufficient confidence for it to be implemented.

Why is radioactive waste management a problem?

1. The production of radioactive waste in the UK began in the 1920s with the early uses of radioactivity in medicine and industry. The quantities increased after the Second World War with the development of nuclear power generation, nuclear weapons and nuclear-powered submarine programmes. Radioactive waste continues to arise today as these applications are ongoing and it will arise in the future as existing nuclear facilities are decommissioned (dismantled and demolished).

2. The range of waste materials that need to be managed in the UK is more complex than in most other countries because of the range of uses (including military), the number of different reactor types and the ways in which the radioactive materials have been treated. For example, the mechanical and chemical separation (reprocessing) of by-products from the nuclear fuel which has been used in a nuclear reactor ('spent fuel') produces separated uranium and plutonium as well as residues of very long-lived, highly radioactive, waste materials.

3. The social and political context of nuclear matters, and radioactive waste in particular, has changed over the past 50 years. There was little or no public concern over waste during the early development of the nuclear industry and the nuclear weapons programme. However, increasingly over time, a number of anti-nuclear organisations (such as the Campaign for Nuclear Disarmament and Greenpeace) have voiced concerns and these concerns have been reflected in a reduction in confidence and trust in the nuclear industry.

4. Radioactive materials and wastes are potentially harmful because they emit ionising radiation, which can damage cells in the body. Very high doses to the whole body can cause death in a short time; high doses to limited areas of the body can cause other immediate local effects; and low doses over extended periods of time can give rise to effects that may not be seen for decades (e.g. induction of cancer). Some materials or wastes are also potentially harmful because of their chemical toxicity, while others, such as plutonium, would additionally have the potential to start a nuclear chain reaction if not properly managed. For these reasons, the management of radioactive wastes and materials is subject to strict regulatory control, in terms of safety, environmental impact and security.

5. There is no internationally agreed method of classifying radioactive wastes. Historically, in the UK they have been categorised in terms of their nature and activity and this has generally been used to determine the approach to waste management. The classification has taken account of the quantity of radioactivity the wastes contain and their heat generating capacity and has resulted in four

basic categories: high level waste (HLW), intermediate level waste (ILW), low level waste (LLW) and very low level waste (VLLW) (see Chapter 2 for detailed descriptions). Unlike several overseas countries, there is no differentiation in the UK between short-lived and long-lived wastes, despite several reports recommending such differentiation[1].

6. Past Government policy has been 'to dispose of radioactive wastes safely at appropriate times and in appropriate ways'[2]. The main current management arrangement for most LLW involves disposal at the national low level waste repository (LLWR) near Drigg in Cumbria. Some low and very low level solid waste is incinerated and some VLLW is disposed of in small concentrations in conventional landfill sites. Both these low and very low level categories are the subject of a separate Government review.[3]

In the context of solid waste, disposal is the emplacement of waste in a disposal facility without intent to retrieve it at a later time.

7. Because there is no disposal of the higher activity wastes (HLW and ILW, and some LLW which cannot be disposed of at the LLWR near Drigg because of its composition), there are already over 80,000 cubic metres (over 100,000 tonnes) of these wastes stored at nuclear sites around the UK, awaiting a Government decision on how to manage them in the long term. The wastes contain a mixture of radionuclides. Some of these will take several hundreds of thousands of years to decay to the level at which the radioactivity poses no measurable hazard to people or the environment.

Box 1.1

Radioactivity is the spontaneous disintegration of unstable atomic nuclei, with loss of energy through emission of charged particles and/or gamma radiation.

Almost all materials are, strictly speaking, radioactive because they contain traces of naturally occurring radionuclides. Radionuclides can also be man-made, most being produced in nuclear reactors.

All radioactivity reduces naturally over time. This is called radioactive decay. The rate of decay is measured by reference to the **half-life**: the time for the radiation emitted to fall by a half. Half-lives of radionuclides vary considerably and can be as short as a few seconds or as long as many thousands or millions of years. Radioactive waste can contain very long-lived material. After 10 half-lives one-thousandth of the activity remains. After 20 half-lives one-millionth remains.

The uses of radioactivity are varied:

- in electricity production from nuclear reactors
- in defence in nuclear submarines and nuclear weapons
- in medicine for diagnosis and for use in the treatment of cancer
- in industry in measurement gauges and process control

The history of disposal

8. The early methods of management of radioactive waste evolved from the 1950s along two main routes – land disposal and sea disposal (in coastal as well as international waters) – with the remainder being stored on the sites where it was generated. In the early 1970s, the UK began to use a deep-sea site 600 miles south-west of Land's End and an annual operation managed by the UK Atomic Energy Authority (UKAEA) took place in which approximately 2000 tonnes of packaged LLW and ILW was disposed of from a chartered vessel.

9. Since the 1976 report of the Royal Commission on Environmental Pollution ***Nuclear power and the environment***[4] and up to 1997, Government long-term policy aim for the management of solid radioactive waste was deep underground disposal. The history has already been recorded elsewhere[5 6] but is summarised here for completeness.

10. As part of the research on HLW disposal, the drilling of boreholes began at a site in Scotland in 1979 and later in Oxfordshire. The drilling programme was discontinued in 1981 as a result of public opposition.

11. In 1982 the Government set up the Nuclear Industry Radioactive Waste Management Executive (Nirex), initially as a co-ordinating committee of the four major organisations in the UK nuclear industry (Central Electricity Generating Board (CEGB), South of Scotland Electricity Board (SSEB), UKAEA, and British Nuclear Fuels (BNFL). This later became UK Nirex Ltd, with the main task of locating, building and running disposal facilities for LLW and ILW. The Government proposed to store HLW for 50 years, mainly to allow it to cool to the point where it could be safely placed underground.

12. Nirex had taken on responsibility for both land and sea disposal but in 1983, following increasing opposition internationally and in the UK, including a vote of contracting parties at the London Dumping Convention, it suspended the practice of sea disposal. It was eventually totally abandoned by the Government in 1993 and is now prohibited under the OSPAR Convention.

13. Nirex then focussed on developing new facilities to dispose of ILW and LLW, proposing a disused anhydrite mine at Billingham, Cleveland, for the long-lived ILW, and a CEGB storage depot from the Second World War at Elstow, Bedfordshire, for short-lived ILW and LLW. Following significant local opposition, the Billingham proposal was withdrawn in 1985 and Nirex was asked to identify a number of sites for co-disposal of LLW and ILW.

14. In 1986, therefore, Nirex put forward proposals for four shallow disposal sites for LLW and short-lived ILW waste in Elstow, Bedfordshire; South Killingholme, Humberside; Fulbeck, Lincolnshire; and Bradwell, Essex. Widespread public opposition in the areas concerned followed, and at about the same time, a House of Commons Committee report, which included a review of operations at the LLWR near Drigg, recommended that future shallow sites should be engineered facilities restricted to LLW[7]. In 1987, the Government and Nirex abandoned shallow sites because of co-ordinated coalitions of protest from the four sites and decided to establish a deep underground site for the co-disposal of ILW and LLW.

15. It was now very clear that radioactive waste management was a social issue. Recognising the public acceptability issues, Nirex undertook a consultation to ascertain the suitability of sites ('The Way Forward'). The sites identified through the process were not revealed – a key example of the secrecy and 'decide–announce–defend' approach of the era. In the event, there was no general support and only Caithness (Dounreay) and Copeland (Sellafield) showed interest in the proposals.

16. In 1989, following this site selection process, Nirex proposed to research only Dounreay and Sellafield as potential sites, and from 1991 concentrated on Sellafield. In 1992 it proposed a rock characterisation facility (RCF) at Sellafield to test the geology and other scientific and engineering issues.

17. Nirex submitted a planning application for the RCF in 1994, but this was refused by Cumbria County Council. Nirex appealed against the decision and after a Public Inquiry, the Inspector recommended against the appeal. As a result, the planning application for the RCF was rejected by the Secretary of State for Environment in 1997. Besides concerns about environmental impacts and local plans, reasons for rejection included scientific uncertainties, technical deficiencies and the way in which the site was chosen.

Time to change the approach

18. The House of Lords[6] carried out a substantial review of where this left the UK. In 1999, it recommended that underground, geological disposal remained the best policy, using a phased approach to develop technical and public confidence; it also recommended that to develop that confidence the Government should draw up a comprehensive radioactive waste management strategy for all wastes and consult the public on its proposed policy as well as the alternative solutions. This should also include a proposed site selection process. The Radioactive Waste Management Advisory Committee (RWMAC) also contributed to the debate with key guiding principles for the process of developing policy, including early involvement of the public (see Overview).

19. The Government recognised that the old approach of 'decide–announce–defend' was no longer appropriate and there was a need to involve stakeholders and citizens at an early stage, address their concerns, and learn from their knowledge and opinions. It decided on a revised approach in 1999: to undertake a more fundamental review of options for managing radioactive wastes in the long term, and to set up an independent body to advise it. The Government's 2001 consultation paper '**Managing radioactive waste safely'**[8] did not present a decision, but a process for reaching one, including a review of long-term management options, a period for decision making and further consultation, to be followed by an implementation programme.

20. The first step, therefore, was to identify the best way of managing the waste, ensuring that this was scientifically and technically sound and could inspire public confidence. The Government – UK environment Ministers, including those from the devolved administrations for Scotland, Wales and Northern Ireland – appointed the Committee on Radioactive Waste Management (CoRWM) in November 2003. Ministers asked CoRWM to undertake a thorough review of all the options for managing the higher activity wastes and recommend an option, or combination of options, that could provide long-term protection to people and the environment, and that could inspire public confidence.

21. Some of the plutonium, uranium and spent nuclear fuel, arising from the nuclear fuel cycle is currently regarded by their owners as having potential future use. CoRWM has also been asked to advise the Government on the implications of treating some or all of these as wastes.

22. The next step, having identified the best approach, will be to establish a clear plan for implementing it, including deciding who will do it, how they will identify any waste management site or sites, and how they will ensure public and stakeholder confidence. This is partly where the previous processes failed, because there was no clear, transparent, logical and trusted site selection process before the search for sites began. This step is for the Government to take following CoRWM's

report. CoRWM's advice on implementation issues (including a process for identifying potential 'host' communities) is covered in Chapter 17 of this report.

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Chapter 2 Identifying the radioactive wastes and materials that the UK has to manage

> The projected volume of higher activity wastes that will arise up to approximately 2120, following decommissioning of existing nuclear facilities, is 478,000 cubic metres (a volume five times that of London's Royal Albert Hall), with a total activity of 78 million terabequerels. Although 92% of the activity is contained in the high level waste and spent fuel, these two categories represent less than 2% of the total volume. The greatest impact on the baseline inventory would be from a programme of new build nuclear power stations. Only a small proportion of the intermediate level waste (1% by volume) can be categorised as short-lived.

1. One of CoRWM's first priorities was to identify how much material might eventually need to be treated as waste, in order to ensure that any option or combination of options recommended can accommodate such wastes. The Committee started from the Government-sponsored UK Radioactive Waste Inventory[1]. Although that document, and the way in which radioactive materials are accounted for, are subject to rigorous control by UK safety and security regulators, it was important for CoRWM to scrutinise it and challenge some of the underlying assumptions. CoRWM consulted stakeholders – including nuclear waste producers and management, central and local government, regulators and environmental groups – before producing a preliminary Inventory Report in 2004[2].

2. CoRWM sought comments on the preliminary report in the first round of Public and Stakeholder Engagement (PSE 1) from November 2004 to January 2005. The comments[3] and the latest national inventory information[4] were taken into account in the preparation of the final version of the report, which was published in July 2005. These data formed the basis for the subsequent assessments of waste management options. Details are given in Annex 3 and in the CoRWM Inventory Report[5], which accompanies this Report.

3. The Inventory Report considers:

    i. the materials that currently exist as waste or could arise over the next century or so as a result of decommissioning of existing nuclear facilities, both in terms of volume and radioactivity

    ii. the characteristics of the materials including any likely technical difficulties that could apply to their management

    iii. the current locations

    iv. any special considerations that apply, such as security.

Box 2.1

Radioactive wastes – the legacy that the UK must manage
(UK material only, eventual projected volume at approximately 2120)

Material	Packaged Volume (m3)	% Volume	Activity (TBq)	% Activity
HLW	1290	<0.3	39 million	50
ILW	353,000	73.9	2.4 million	3
LLW (Non-Drigg [1])	37,200	7.8	<100	<0.001
Plutonium (Separated)	3,270	0.7	4 million	5
Uranium	74,950	15.7	3,000	<0.01
Spent Fuel	8,150	1.7	33 million	42
		Total		**477,860**

[1] Low level waste that cannot be disposed of in the LLWR near Drigg because the radioactive content or physical/chemical properties do not meet the site acceptance criteria.

The main components of the inventory

4. **High level waste** is very radioactive, mainly fission products, and generates a great deal of heat. This heat generation has to be taken into account when storing HLW and designing facilities for its management in the long term. HLW arises at Sellafield as a highly radioactive nitric acid liquid waste solution following the separation of uranium and plutonium from spent nuclear fuel during reprocessing. These liquid wastes are being converted into a passively safe solid form, as borosilicate glass within 150-litre stainless steel containers, using a process called vitrification. Once vitrified, the wastes are currently to be stored for at least 50 years to let the heat-emitting radionuclides decay to levels that facilitate long-term management. In a programme agreed by the site operators and the nuclear regulators, by 2015 the majority of the backlog of high level liquid waste stockpile will have been vitrified. A smaller volume of liquid waste (currently required by the regulators to be a maximum of 200 cubic metres) will then be maintained to facilitate ongoing site operations and decommissioning, before eventually being vitrified. When in liquid form, the wastes require active management and control, including the provision of continuous engineered cooling because of the heat generated, and substantial shielding because of the very high radiation levels. Once vitrified, the solid waste is passively stored in naturally cooled, shielded concrete stores.

5. **Intermediate level waste** is less radioactive than HLW, and does not generate sufficient heat for this to be taken into account in the design of the facilities for management, but can require significant shielding. Some of the waste can have very long half-life. The form of the waste is much more varied than HLW. Major components include metal items, such as nuclear fuel cladding and reactor components, graphite from reactor cores and sludges from treating radioactive liquid effluents, as well as some wastes from medical and industrial users. It is stored in tanks, vaults and drums, usually with some shielding to protect operators from radiation. Waste is progressively being immobilised in cement-based materials within 500-litre stainless steel drums or, for larger items, within high capacity steel or concrete boxes.

6. **Reactor decommissioning waste (RDW).** Some of the ILW that will arise in the future from reactor decommissioning is relatively short lived (<30 year half-life). This material would decay to LLW in around 300 years and could be considered for co-disposal with LLW in any future shallow disposal facilities that may follow the LLW review[6]. Some of this RDW may contain waste, which is longer lived (i.e. would be present well after 300 years). If this was present in relatively small concentrations, it might be possible to make a case that this would not pose a significant hazard after 300 years.

7. **Low level wastes** are less radioactive than ILW, and consist largely of redundant equipment, protective clothing and packaging. In future, as nuclear plants are decommissioned, the main components will include soil, concrete and steel items such as ducting, piping and reinforcement. Most of the existing LLW is disposed of at the national LLWR near Drigg in Cumbria. It is compacted, packaged in large metal containers and put in an engineered vault a few metres below the surface. Some LLW that does not meet the LLWR site acceptance criteria because of its radioactivity or physical/chemical properties, is included in the inventory that CoRWM is considering.

8. **Naturally occurring radioactive materials (NORM)** contain radioactive elements such as uranium and thorium (which came into existence when the earth was formed) and their radioactive decay products. The majority of NORM arises from non-nuclear industrial processes in very large quantities but low specific activity. The main area of particular interest is the solid radioactive waste, containing low activity radium scales, that arises from the oil and gas industry. The waste may not meet the conditions for disposal at the LLWR near Drigg, but there is currently one shore-based facility that is authorised to discharge these low activity radium scales to the marine environment. The generation of NORM from a variety of non-nuclear industries could potentially have important consequences for LLW disposal capacity.

9. **Plutonium** is created as a by-product of the use of uranium fuel in nuclear reactors and is used in nuclear weapons. It can represent a significant health hazard if inhaled or ingested. It is contained within spent fuel when it is removed from a reactor, but can be extracted by reprocessing the spent fuel. It could, in this extracted form, be used to make some reactor fuels. The UK's stockpile of plutonium is stored at Sellafield and future arisings from reprocessing will be stored at the same place. The Nuclear Decommissioning Authority (NDA) is evaluating the options for managing this stockpile, which include consideration of use in reactor fuel and various methods of encapsulating it as a waste[7].

10. **Uranium** is found naturally, and can be processed to give highly enriched, low enriched and depleted uranium (these forms having different concentrations of uranium-235). It is also a product of the reprocessing of spent fuel and can have similar uses to plutonium. Less radioactive ('depleted') uranium has a wider range of uses, including artillery shells and aircraft counterweights. Uranium is stored at a limited number of British Nuclear Group (BNG) and UKAEA sites (see Figure 2.3) and future arisings from reprocessing will occur at Sellafield. As with plutonium, the NDA is evaluating options for managing this stockpile. The vast majority of the uranium inventory is depleted and the potential risks associated with this material are considerably less than most other materials in the CoRWM inventory.

11. **Spent nuclear fuel** is a mixture of plutonium, uranium and waste materials. It can be reprocessed to extract the plutonium and uranium; or it can be managed in another way, such as packaging it and placing it in a waste repository, as is planned in a number of countries that have nuclear power stations. The UK stocks of non-reprocessed spent fuel consist of arisings from Magnox and Advanced Gas-cooled Reactors and from the Sizewell B Pressurised Water Reactor, along

with submarine reactor spent fuel and smaller quantities of specialist fuel from research and prototype reactors.

Scenarios that could affect the inventory

12. The Inventory Report also looks at the impact on the inventory of possible future scenarios and uncertainties, including the following:

- **New build.** This is the amount and type of waste that could arise if further nuclear power stations were built. The scenario chosen was of ten new AP1000 nuclear reactors which could use up the UK's separated plutonium stockpile in the form of mixed-oxide (MOX) fuel and create a MOX spent fuel waste stream. Chapter 18 sets out the Committee's view on how new nuclear build could negatively affect the successful implementation of any radioactive waste strategy.

- **Waste substitution.** High, intermediate and low level waste is produced when spent fuel from abroad is reprocessed in the UK. Contracts require that these wastes be returned to the country of origin. The waste substitution policy allows the addition of some UK HLW to the overseas HLW that is to be sent back to the country of origin, to compensate for a radiologically equivalent amount of the overseas ILW and LLW that is retained in the UK. This leaves each party with the same amount of waste in radiological terms but significantly reduces the number of waste transport shipments required.

- **Decontamination, storage for decay, and segregation of intermediate level waste**. This involves waste producers decontaminating or decay-storing suitable ILW streams (or segregating some components of these streams) so that they can eventually be disposed of at the LLWR.

- **Life extensions** of five years for existing Advanced Gas-cooled Reactor stations and ten years for Sizewell B.

- **Early closure** of fuel reprocessing plants and early decommissioning of nuclear reactors. This could involve early closure of Magnox plants but continued reprocessing of their spent fuel.

- **Naturally occurring radioactive materials (NORM).** Although this category of waste is not within the CoRWM remit because there is one current disposal route to sea, there are uncertainties of whether this route will continue to be used. The waste is LLW, but the radium content may make it unsuitable for disposal at the LLWR. Alternative routes of disposal could be sought following the LLW review.

The volume and activity of wastes

13. CoRWM's Inventory Report estimates that the amount of wastes which will eventually have to be managed will total approximately 478,000 cubic metres (a volume five times that of London's Royal Albert Hall) and an activity of 78 million terabequerels once they are conditioned and packaged. Approximately 80,000 cubic metres of the inventory have arisen already; the remainder will arise at various times over the next 100 years or earlier, as the decommissioning of existing nuclear facilities progresses.

14. ILW makes up approximately 74% of the volume of the CoRWM inventory, uranium approximately 16% and the other categories in total approximately 10%. While the combined volume of HLW and spent fuel is less than 2% of total volume, they comprise 92% of the total radioactivity (HLW 50%, spent fuel 42%). HLW is

now only located at Sellafield, and spent fuel will principally be located at Sellafield and Sizewell. ILW arises at all the 36 major waste producing sites in the UK. In terms of the total volume of ILW projected, Sellafield accounts for approximately 43%, the eleven Magnox stations account for 28%, the seven AGR power stations 16% and Dounreay 4%.

15. The total volume is unlikely to vary by more than 10% for any of the scenarios considered. The greatest impact on total activity would come from a programme of new nuclear power stations – it could rise by a factor of nearly three as a result of construction of ten reactors because of the spent fuel. If spent fuel was not reprocessed, but declared a waste, then the spent fuel element of the total waste inventory would be approximately five times greater in volume and radioactivity than the present anticipated quantity. If plutonium were used as MOX fuel this would also affect the amount and chemical form of the plutonium within the total inventory.

16. If plutonium and uranium were declared wastes, this would have little impact on the overall size or radioactivity of the inventory. But their management would need to reflect the composition of the materials including criticality and security risks.

17. Only a small proportion of the ILW inventory volume (about 1%) can be categorised as short-lived and so would potentially be suitable for near surface disposal. Furthermore, the impact of attempting to segregate more waste for near surface disposal would be likely to be very modest.

18. Submarine spent fuel is presently stored at Sellafield in ponds and is not designated as waste. The Ministry of Defence, its owner, has no plans to dispose of the spent fuel. The Ministry, however, has said that it does not envisage that there would be insurmountable problems associated with long-term dry storage of the fuel. If it was decided that submarine spent fuel was to be emplaced in a long-term store with civil fuel, it would need to be in a separate vault from civil fuel in order to ensure security and separation for safeguard accounting. To place this management issue in context, the total quantity of submarine spent fuel that could be managed in 2040 is equivalent to only a small fraction of the stockpile of pressurised water reactor spent fuel from Sizewell B[8].

Chart showing volume contributions to the baseline inventory

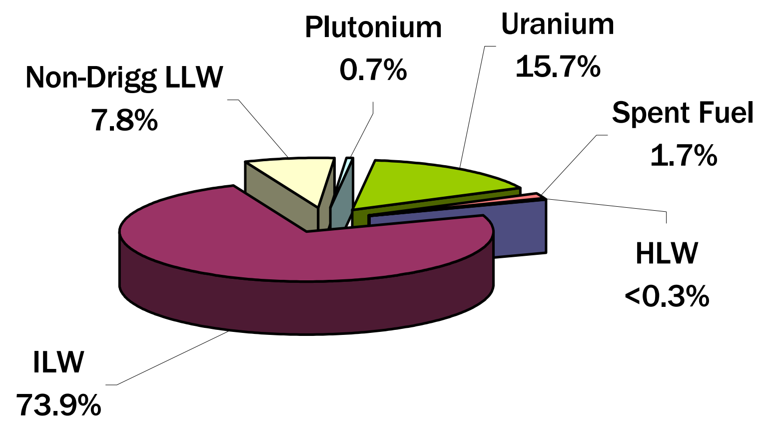
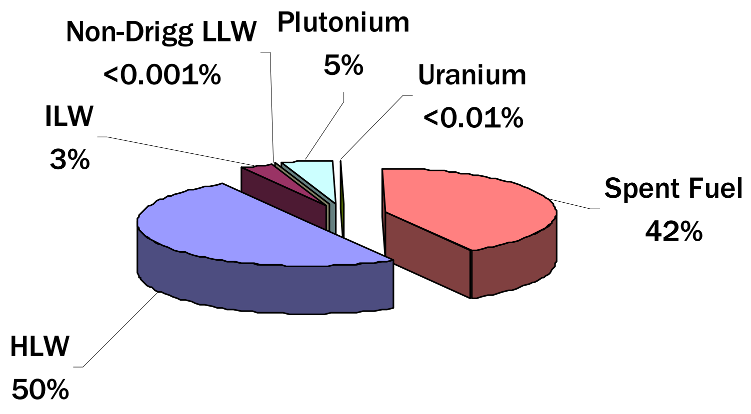


Chart showing radioactivity contributions to the baseline inventory



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Chapter 3 Other current initiatives in the development of policy

There are a number of concurrent Government and other initiatives which potentially impact on CoRWM's work. The Committee has maintained contact with those involved and taken relevant information into account in developing the CoRWM recommendations.

1. CoRWM has been working to recommend long-term management options for all solid radioactive wastes except those at low levels of radioactivity. Deciding on these options is a major part of the radioactive waste policy agenda, but there are other issues in radioactive waste management, especially in the shorter term, including decommissioning. This in turn means that there are many other initiatives which affect CoRWM's work and which have been taken into account.

2. The Government set up the NDA in 2005 to take strategic responsibility for the UK's nuclear legacy (principally owned previously by BNFL and UKAEA). The NDA's main task is to ensure that the civil public sector nuclear sites of BNFL and UKAEA are decommissioned and cleaned up safely, securely, cost effectively and in ways that protect the environment now and in the future. The NDA is overseeing the management, in the short term, of much of the waste on which CoRWM is making long-term recommendations. The NDA has to make judgements, for example, about investing in storage facilities with a lifespan of many decades, and its decisions will be substantially affected by CoRWM's recommendations and the Government's reaction to them. CoRWM and NDA have met regularly to exchange information on technical and stakeholder issues, and to ensure that CoRWM's review of options is not constrained by any of the NDA's proposals. The NDA is also responsible for the long term management of LLW at the LLWR near Drigg.

3. In 2005, the Government also initiated a review of LLW management policy.[1] Many nuclear and other facilities need to be decommissioned over the next few years, yielding a large volume of wastes. These are currently managed in different ways and places, including the LLWR. The review is considering such issues as the limited capacity of the LLWR, the nature of the various wastes and how different types of waste could be best managed – including removing the potential need for transporting large volumes of relatively low activity waste over long distances. While CoRWM is considering only higher activity waste, the LLW review has implications for reactor decommissioning wastes and the consideration that the NDA is giving to the local management of LLW at its sites.

4. The Government published its latest energy policy review in July 2006 at a time when CoRWM was finalising its recommendations.[2] In the review, the Government conclude that "new nuclear power stations would make a significant contribution to meeting our energy policy goals" and that the Government will take steps to improve the planning process for all energy infrastructure. Should more nuclear reactors be built, this would add to the waste inventory, extend the period during which waste management facilities have to operate for an indeterminate period and could affect public confidence in the waste management programme being proposed by CoRWM for current waste. Any proposed changes to the planning process would also need to be considered as to whether they have any implications for CoRWM's implementation recommendations. CoRWM considers that the social, political and ethical challenges relating to any new nuclear build, and waste generated, could be greater than the technical challenges (see Chapter 18).

5. The Government has examined options for managing non-military plutonium and will be guided by the advice of the NDA. The result could affect the amount of plutonium that has to be managed as a waste – though even if plutonium were to be used in nuclear fuel, there would eventually be more waste to be managed.

6. Nuclear submarines, which have been removed from service with the Royal Navy and defuelled, contain ILW within their reactor compartments. Arrangements for the interim storage of this waste prior to its eventual disposal are being developed by the Ministry of Defence through Project ISOLUS (Interim Storage of Laid-Up Submarines) set up in 2000. In response to public consultation3 and in order to ensure a cross-Government approach to radioactive waste management, the Ministry aligned the ISOLUS process closely with CoRWM's deliberations. Future decisions on the project will be made in the light of CoRWM's recommendations to Government.

7. The SAFEGROUNDS project (1998)[4] has involved civil and nuclear site operators, Government, stakeholders and others in developing and disseminating good practice and guidance for managing radioactively and chemically contaminated land. As with ISOLUS, CoRWM has kept in touch with the organisers to share experience about PSE activities and avoid duplication.

8. The Government reviewed its waste substitution policy and announced its decision in 2004.[5] Substitution is considered to be a controversial issue. Contracts for reprocessing overseas spent fuel at Sellafield specify that all reprocessing products, including ILW and HLW, are to be sent back to their owners. No such returns of wastes have yet taken place. Under substitution arrangements, now approved in principle by Government, the UK would be able to retain overseas LLW and ILW from reprocessing and return, on top of the HLW already in overseas ownership, an additional amount of HLW equivalent in radioactivity to the ILW retained in the UK. Thus, the overseas owners will receive back, in a concentrated form in HLW, the same amount of radioactivity as that contained within the original spent fuel. The major motivations for substitution are cost savings and reduced international transport. This new policy would change, by a small margin, the amount of waste needing to be managed in the UK; there will be a slightly smaller volume of HLW but a larger amount of ILW – the Government estimates about 1.4% more by volume. So the overall volume managed in the UK would increase slightly, but the total radioactivity would not (see the CoRWM Inventory Report [6]).

9. In 2005, the Government took ownership of UK Nirex Ltd, which since 1997 has been providing advice on the conditioning and packaging of waste, compiling the UK Radioactive Waste Inventory jointly with Defra, and maintaining the UK's stock of knowledge on geological disposal of radioactive waste. It has been an important information source for CoRWM, especially in relation to the geological disposal options. In 2005, Nirex also published the list of potential repository sites it had considered during the 1980s and early 1990s.[7]

10. An independent body, the Radioactive Waste Management Advisory Committee (RWMAC) was set up in 1978 and advised on radioactive waste policy issues generally. It was put into abeyance in 2004 after CoRWM was set up to recommend a long-term policy for solid wastes. There is currently no independent committee advising Government on all types of radioactive wastes including their current management.

11. Many of these developments are interrelated. The Government has set up an interdepartmental Radioactive Waste Policy Group and an Implementation Planning Group to consider these and other issues including CoRWM's recommendations and what policy or organisational changes should follow.[8]

References

1 Department for Environment, Food and Rural Affairs & others, "A Public Consultation on Policy for the Long Term Management of Solid Low Level Radioactive Waste in the United Kingdom", February 2006. See also Defra website http://www.defra.gov.uk/environment/radioactivity/waste/index.htm

2 Department of Trade and Industry, "The Energy Challenge: Energy Review Report 2006". See also DTI website http://www.dti.gov.uk/files/file31890.pdf.

3 Ministry of Defence, "Interim Storage of Laid Up Submarines: Consultation on ISOLUS Outline Proposals: Ministry of Defence Response to Lancaster University's Final Report", February 2005. See also ISOLUS website http://www.lancs.ac.uk/users/csec/isolus2/isolus%20history

4 CIRIA, "The Safegrounds Learning Network", 2006. See Safegrounds website http://www.safegrounds.com.

5 Department of Trade and Industry, "Intermediate Level Radioactive Waste Substitution", December 2004. See also DTI website http://www.dti.gov.uk/files/file30058.pdf.

6 Committee on Radioactive Waste Management, "CoRWM's Radioactive Waste and Materials Inventory", July 2005, CoRWM Document No. 1279.

7 UK Nirex, "Nirex publishes historic site list", 10 June 2005. See also Nirex website http://www.nirex.com/index/iold_list.htm.

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Chapter 4 CoRWM's principles and practice

At the start of its work, CoRWM drew up a set of five principles to guide every aspect of its work. These principles have been applied both to the way the Committee itself worked, and in the approach to the process of engagement with the public and stakeholders.

1. Principles may be described as statements of fundamental core values. CoRWM's five principles have underpinned everything that the Committee has done. They are:

   i. **To be open and transparent**. Our aim is to earn public trust by securing confidence in our actions. Openness requires that we operate in public and are accessible both in person and through our publications. Transparency means that we aim to make as clear as possible how, and why, we have formulated our recommendations. This principle is reflected in our publication scheme and transparency policy.

   ii. **To uphold the public interest by taking full account of public and stakeholder views in our decision making.** Our objective is to identify and evaluate the options and decide on the recommendations for the future management of radioactive waste. We shall achieve this through encouraging discussion and deliberation with the public, local political representatives and a wide range of stakeholders. Through this process, we aim to make recommendations that are both practicable and acceptable.

   iii. **To achieve fairness with respect to procedures, communities and future generations**. We consider fairness (equity) to be fundamental in order to inspire public confidence. We shall try to ensure that anyone who wants to participate in the process has the opportunity to do so. We shall strive to avoid favouring particular groups, stakeholders, communities or regions. But we also recognise that some may have a greater interest in the process and its outcomes than others, for example, people living close to sites where waste is currently managed. Fairness also involves recognising the rights of future generations.

   iv. **To aim for a safe and sustainable environment both now and in the future.** This principle applies to present and future generations and embraces the natural, as well as the human, environment. In seeking to fulfil this principle, we recognise the need to apply the best available sound science and other specialist input and acknowledge that achieving a safe and sustainable environment requires its integration with social science through an interdisciplinary approach. We accept that proposals for the long-term management of radioactive wastes should seek to avoid placing undue burdens on the environment, both now and for future generations.

   v. **To ensure an efficient, cost-effective and conclusive process**. We recognise we must operate within resource and time constraints. We must maintain the direction and objectives of the programme, keeping within budget and reaching conclusions within an appropriate timescale. We will ensure that other matters that are raised are considered in appropriate ways. But, above all, we will endeavour to present recommendations which have broad support and which we believe will provide a solution to the problem.

Practices that have evolved from these principles include:

2. Taking a deliberative approach, both in Committee discussions and in working with citizens, specialists and stakeholders. Deliberation can be defined as a process of 'arriving at common judgements on common interests founded on reasons and argument'.[1] It can contribute significantly to decision making by uncovering and examining the reasons why people hold certain views. The outputs from a deliberative

process can be integrated with the results of other approaches to help formulate policy recommendations. CoRWM held a deliberative democracy and decision-making workshop [2] which was led by academics specialising in politics. A key aspect of deliberation is that it encourages the free expression of ideas, views and beliefs, and is a vehicle for identifying and understanding what people think and what is important to them. While there is an obvious need for robust scientific knowledge when dealing with the issue of radioactive waste, there are inherent uncertainties in such a complex topic. Other forms of knowledge based on experience and values are an important input into decision making. One of the outputs of the workshop was an acknowledgement that deliberative processes are a way of establishing mutual respect and trust between expert and lay knowledge and opinion.

3. **Recognising that there is a very strong ethical dimension to the issue of radioactive waste**. Why radioactive waste is an ethical issue and what that might mean for the Committee's work was explored at another workshop with a panel of national and international ethicists.[3] Among the key ethical principles identified as relevant to CoRWM's work were: respect for life, concern for well-being, ensuring justice, and respect for dignity and liberty. These principles require consideration of such issues as intergenerational equity (the distribution of burden over time), intra-generational equity (fairness between communities), and the environment. As the Committee's work progressed, these difficult moral and ethical issues increasingly influenced our discussions and conclusions (see Chapter 6).

4. **Using all appropriate sources of information.** Constituting a Committee made up of people with very diverse backgrounds and experience, the members themselves possessed a wide range of knowledge and expertise on which to draw. CoRWM recognised that it would use the large amount of research that had been carried out in the field of radioactive waste management in the UK and internationally. CoRWM aimed to act as an intelligent customer in commissioning and evaluating work which drew on this experience. In addition, Committee members visited the two principal nuclear sites in the UK – Sellafield and Dounreay – as well as sites in Sweden and Finland, where the management of radioactive waste is more advanced (see Chapter 9).

5. **Making CoRWM's process open and transparent**:

   - One of the Committee's first actions was to draw up a transparency policy which can be viewed on the CoRWM website.[4] The policy explains CoRWM's aim of making as clear as possible how and why it came to its recommendations.

   - The transparency policy was complemented by a publication scheme[5] which explains how the various types of information used or generated by the Committee could be accessed by the public. Only a very small number of documents covering commercial contracts are not accessible.

   - CoRWM held its plenary meetings in public, as far as practicable moving the location of meetings around the country in order that people interested in listening to members speak were able to do so. Option assessment was carried out in public – possibly for the first time in the UK. Opportunities for people to ask questions were provided at all meetings.

   - CoRWM set up a website (www.corwm.org), which advertised forthcoming events, provided opportunities to comment on work, gave updates and bulletins on process, and included a search engine for finding and downloading documents.

6. **Being Efficient.** While recognising that it was set up as an overseeing committee, CoRWM discovered that in order to get the work done, members had to do a

considerable amount of work themselves. The Committee sought to make best use of its time and members' expertise by forming working groups to work on specific issues as delegated by the full Committee. The structure, role, and membership of these working groups changed as the Committee's work progressed. When necessary, appropriate specialists were co-opted onto working groups for specific tasks. The working groups took on specific areas of work, operating in parallel with one another and reporting to plenary meetings on the results. The areas of work carried out in this way were:

- establishing guiding principles
- scoping and describing the CoRWM inventory
- design and management of PSE
- gathering information enabling options to be compared
- designing option appraisal methodologies
- providing advice on implementation
- quality assurance of CoRWM's work
- content and management of the CoRWM website.

Reports from working groups to plenary can be found on the CoRWM website.

7. **Ensuring Quality.** CoRWM established a Quality Assurance working group to oversee quality assurance and to ensure that the work was of good quality and would lead to robust recommendations to Government. As well as some CoRWM members, the group included independent academics proposed by the Royal Society and the Royal Academy of Engineering. CoRWM's quality assurance arrangements were formalised to ensure that the key parts of the programme were delivered in an efficient and timely way. They include four basic elements: delivering outputs on time; ensuring the quality of specialist or technical reports; ensuring the quality of CoRWM's processes; and ensuring learning from experience.

8. **Evaluating and learning**. CoRWM's work has been independently evaluated by Faulkland Associates, who produced regular evaluation reports on specific aspects of CoRWM's programme.[6] Strengths and particularly weaknesses pointed out in these reports have been used when planning subsequent activities. CoRWM evaluated the events it held, both by asking those involved to provide feedback, and by holding debriefing sessions. The resulting lessons were used when planning future events.

References

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2 Committee on Radioactive Waste Management, "Deliberative democracy and decision making for radioactive waste", 2005, document 1346.

3 Committee on Radioactive Waste Management, "Ethics and Decision Making for Radioactive Waste - A Report for CoRWM", 2006, document 1692

4 Committee on Radioactive Waste Management, "Transparency Policy". See CoRWM website at http://www.corwm.org.uk/content-264.

5 Committee on Radioactive Waste Management, "Publication Scheme". See CoRWM website at http://www.corwm.org.uk/content-265.

6 Faulkland Associates, "CoRWM Phase 2 Evaluation", October 2005, as an example. See CoRWM website at http://www.corwm.org.uk/content-595.

Chapter 5 Key steps in the programme

CoRWM developed a wide-ranging programme of activities to enable it to assess the options for managing radioactive waste in the long term and formulate its recommendations to government. This chapter gives a broad overview of the key steps in the programme to set subsequent chapters in context.

Overview of the programme

1. CoRWM's terms of reference (see Annex 1) required the Committee to supply recommendations by no later than the end of 2005. As the process of setting up the Committee took longer than anticipated, the original programme of work submitted to Government proposed a reporting date of November 2006. Government asked whether this could be brought forward to July 2006, which CoRWM agreed to do. This compressed timescale has necessitated an intense programme of work, and significant parallel working. A revised programme of work evolved over time, the key steps of which are shown in Figure 5.1. This illustrates the critical and continuous input from the scientific community, specialists, stakeholders and the public.

2. CoRWM divided its programme into three phases. The first phase ran until September 2004 and was primarily focussed on information gathering, testing methods, drawing up the long list of potential options for managing radioactive waste and deciding how to undertake a shortlisting process. The second phase from September 2004 until July 2005 included the shortlisting process and deciding how to assess that shortlist. The third and final phase lasted a year from August 2005 until July 2006 and included the assessment of the shortlisted options, the formulation of recommendations, and drafting the report to Government. The various activities that took place within these phases, sometimes spreading across all three phases (e.g. identifying the inventory of waste) are briefly described below.

Information gathering and pilot testing

3. CoRWM began by gathering information and learning about the issues. In terms of public and stakeholder engagement, the Committee learned lessons from the events surrounding the oil platform Brent Spar, and from the 'GM Nation?' debate about genetically engineered crops.[1]

4. CoRWM studied material, visited establishments and organisations in the UK and abroad, and paid particular attention to meeting the requirement in its terms of reference to 'engage members of the UK public, and provide them with opportunity to participate'.[2] With this in mind, the Committee trialled a technique called Deliberative Mapping (DM), which is a participative, multi-criteria, option appraisal process developed by researchers at University College London and the University of Sussex.[3] Although the Committee decided not to adopt the DM process in total, many lessons were learned about how to interface with specialists, stakeholders and the public, and several techniques used in the DM trial were adopted later in CoRWM's process. The Committee also commissioned a comprehensive review of methods for engaging with the public and stakeholders.[4]

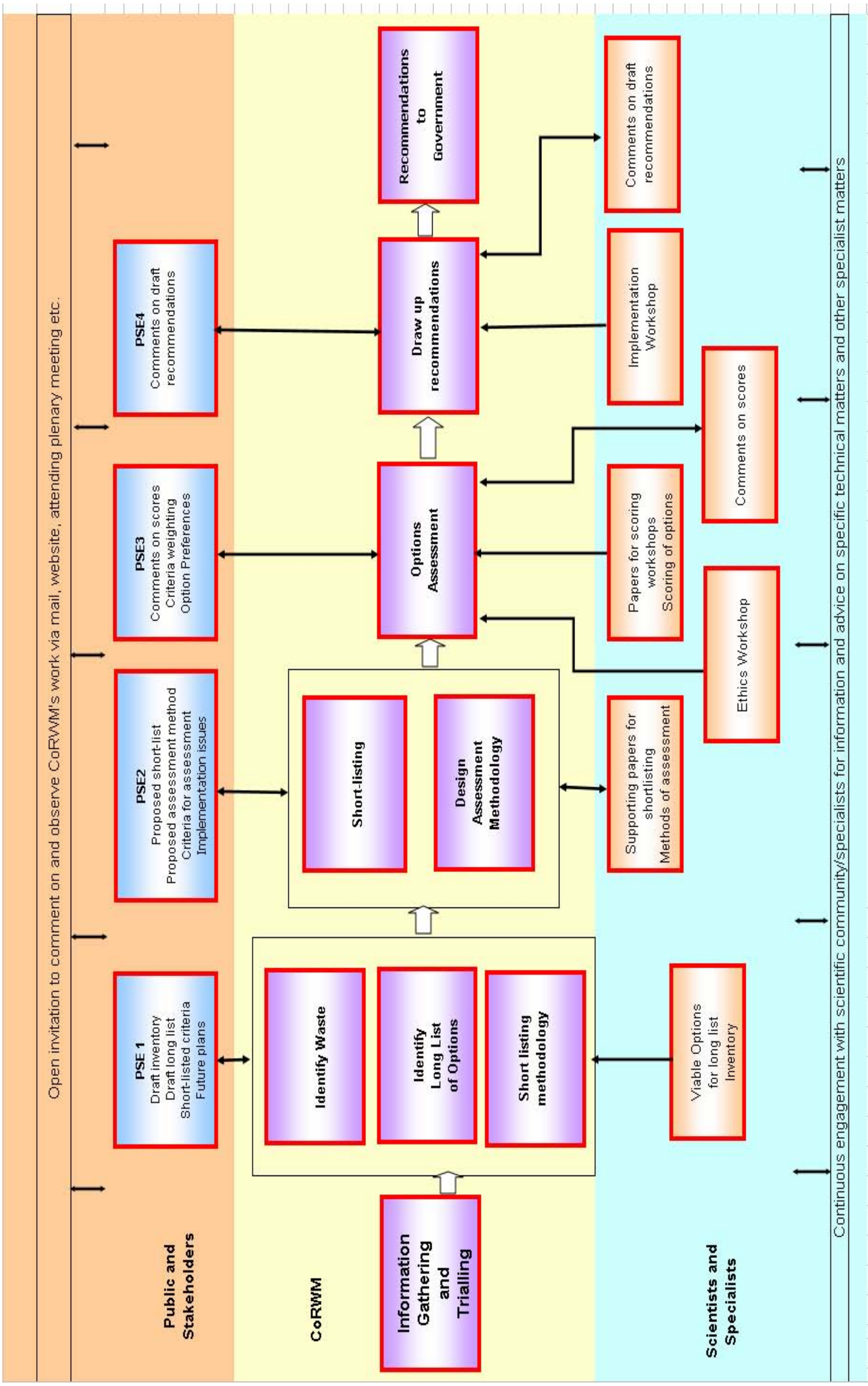

Figure 5.1 Key Steps in CoRWM's Process

Identifying the waste to be managed

5. An early task was to identify the quantity and location of radioactive waste and materials that came within CoRWM's remit. Appropriate specialist organisations were consulted and a draft inventory of waste was drawn up.[5] Comments on this draft inventory were then invited.[6] Chapter 2 describes the identification of the inventory of waste, and addresses some of the issues that were raised by stakeholders and the public, including the impact of potential nuclear new build, substitution and reprocessing.

Identifying a long list of options

6. Government asked CoRWM to identify the options for the longer term management of the various waste materials based on public and stakeholder views. A long list of options had already been drawn up by a team of consultants working on a previous project,[7] and this had been widely reviewed. These options had therefore been considered viable by the international scientific community and were put out for further public and stakeholder comment and specialist review to ensure that there were no significant omissions.

Integrating ethical issues

7. Radioactive waste management decisions have fundamental ethical dimensions. CoRWM recognised early on the importance of making the relevant ethical issues explicit. It organised a two-day workshop for members on ethics and radioactive waste, and deliberated on the issue with four internationally recognised ethical experts on the subject. CoRWM ensured that ethical issues remained prominent throughout its process, and Chapter 6 describes the substantive questions involved.

Shortlisting

8. At the same time, people's views were sought on how the long list should be assessed to create a shortlist. In particular, the public and stakeholders were asked to comment on CoRWM's proposed shortlisting criteria.

9. CoRWM commissioned a number of short technical briefing papers to draw on existing scientific knowledge to provide information to assist in shortlisting the options, and asked the public and stakeholders for their views on the emerging shortlist.[8] Feedback from this consultation informed discussions that led to an agreed shortlist. Chapter 10 describes the shortlisting process.

Assessing the shortlisted options

10. CoRWM commissioned work to identify different methods that might be used to assess the shortlisted options, and co-opted specialists onto the working group that designed a bespoke methodology. To ensure that this proposed methodology had wide agreement, comments were invited, and feedback was used to optimise the process. Annex 4 provides more detail on how the assessment methodology was designed.

11. Using an innovative approach based on the Co-operative Discourse Model developed by Ortwin Renn[9], CoRWM undertook two separate processes to enable it to assess the shortlisted options: a Multi-Criteria Decision Analysis (MCDA) process and an holistic assessment process. The outputs from both of these processes were used to inform CoRWM's own option assessment deliberations as part of formulating its recommendations. For the MCDA process, CoRWM involved approximately 70 specialists in scoring the options against the criteria that had

been drawn up after consultation with the public and stakeholders. This included commissioning papers designed to give the specialists additional information they requested to assist them in their task. Members of the public and stakeholders were also involved in the assessment processes. For MCDA, they provided input into the weighting of the criteria and for the holistic assessment they gave their option preferences and supporting reasoning[10]. An opportunity to comment on the specialist scores was offered on the CoRWM website. Chapter 11 describes the assessment process in detail.

Implementation issues

12. In parallel with its options assessment process, CoRWM conducted substantial work on implementation issues, commissioning external expert analysis as well as using Committee expertise. This included a two-day implementation workshop for members. The detailed results of the implementation work are contained in the accompanying report[11] and the main conclusions are in Chapter 17.

Integration and drawing up recommendations

13. CoRWM needed to integrate all the inputs it had received from its many activities and deliberations in deciding on its recommendations. In this integration process CoRWM considered the outputs from the two methods of assessment, and took into account scientific, ethical and PSE opinions. Integration was itself a deliberative process and it led to the formulation of the recommendations. These draft recommendations were then put out for public and stakeholder comment (PSE4).

14. CoRWM reviewed all the comments received on its draft recommendations and submitted its final recommendations to Government on 31 July 2006.

References

1 Committee on Radioactive Waste Management, Minutes of 2nd Meeting, 8-9 December 2003 (CoRWM document 27). See CoRWM website http://www.corwm.org.uk/content-120

2 see, for example: Committee on Radioactive Waste Management, reports on meetings with Greenpeace, 5 March 2004 (CoRWM document 653), Ministry of Defence, 12 March 2004 (doc. 654), nuclear regulators, 26 March 2004 (doc. 655), and visit to UKAEA Dounreay, 30 June-2 July 2004 (doc. 666)

3 Faulkland Associates, "Evaluation of the Deliberative Mapping Pilot - A Report for CoRWM", document 586, August 2004

4 Hunt, J. "Review of Intensive Public and Stakeholder Engagement Methods", document 660, August 2004

5 Committee on Radioactive Waste Management, "Preliminary report on the Inventory", document 542, 2004

6 Committee on Radioactive Waste Management, "Public and Stakeholder Engagement 1: Consultation Document", November 2004.

7 Committee on Radioactive Waste Management, "Information Needs Research Project - Background Note for CoRWM", document 32, 2004. For the full report, see:

Department for Environment, Food And Rural Affairs, Commissioned Research for Radioactive Substances Division: "Identification of Information Needed to Decide with Confidence on the Long Term Management of Options for Long Lived Radioactive Waste", 2002 - on Defra website at: http://www.defra.gov.uk/environment/radioactivity/publications/complete/pdf/defra_ras-02-014.pdf

8 Committee on Radioactive Waste Management, "How should the UK manage radioactive waste? 2nd Consultation Document", April 2005.

9 Renn, O., "Analytic-deliberative Processes of Decision Making: Linking Expertise, Stakeholder Experience and Public Values" , document 847, 2004

10 See CoRWM website www.corwm.org.uk/content-986 for details of reports from citizens' and stakeholders' events

11 Committee on Radioactive Waste Management, "Moving forward: CoRWM's proposals for implementation", document 1703, July 2006.

Chapter 6 An ethical problem

Radioactive waste is an ethical issue and CoRWM placed ethics at the heart of its deliberations. Ethical concerns about responsibility for future generations influenced CoRWM's thinking on the choice between dealing with radioactive wastes now or leaving it for future decision. Ethical arguments were also important in defining ideas of participation, partnership and compensation that are the basis for the Committee's proposals for implementation. On the question of new build, a clear ethical distinction can be made between dealing with existing and unavoidable wastes and the creation of new wastes.

1. Ethics are sets of principles or standards concerned with behaviour and well-being. They act as a guide to what is acceptable or unacceptable, what we should do, what is right or wrong, good or bad. Ethics are about how we ought to act in contexts that have significant implications for human and non-human lives and well-being.

2. Radioactive waste is an ethical issue for several reasons. It is associated with nuclear energy, nuclear weapons, the dangers of proliferation and terrorism, all of which raise ethical concerns. Radioactivity impacts unevenly between places and across generations and raises ethical issues of fairness. It is also an ethical issue because its longevity and complexity place it in the realm of both science and values. In making option assessments it is necessary to combine both empirical and ethical knowledge, facts and values.

3. Ethical positions are informed by values and may be stated as principles. The ethical principles of primary concern to CoRWM are those embraced in two of its guiding principles (see Chapter 4). One is the principle of equity. Equity is a core value embedded in Guiding Principle 3, to achieve fairness with respect to procedures, communities and future generations. In choosing options, it is necessary to consider the implications and impacts of decisions for present and future generations. The other key principle is that of sustainability identified in Guiding Principle 4, to aim for a safe and sustainable environment both now and in the future. Concerns about equity, sustainability and safety are at the heart of deliberations about options.

4. CoRWM has therefore put considerable emphasis on the importance of ethics throughout its programme of work. Ethical concerns informed the criteria used in the shortlisting process. During the options assessment phase of the programme, stakeholders and citizens were invited to apply a set of ethical questions as part of their holistic assessment. The Multi Criteria Decision Analysis (MCDA) was a systematic assessment involving a specialist input in which value judgements also played a major part. It was recognised that ethical issues play a role in evaluating the importance of criteria such as safety, security, flexibility and burden on future generations (see Chapter 11).

5. As part of its preparatory work, the Committee held a two day workshop where members were able to engage in ethical deliberations with a panel of ethicists. The contributions of the panel and the discussions at the workshop are reported simultaneously with this Report.[1] The workshop was a significant input to the overall assessment performed by members which led to the strategy for long-term management of wastes that is proposed in this report. Ethical considerations have played a significant role in CoRWM's decision making, both on the best option for the management of radioactive waste, and also on how the option can be successfully implemented.

6. During the discussions at the workshop, some fundamental ethical principles were identified. These included the principles of well-being, of justice and of dignity. Well-being represents a utilitarian approach and emphasises the need to maximise good impacts and to minimise harmful ones. Justice is a distributional principle focussing on the norm of fairness in the distribution of burden. The principle of dignity relates to ideas of autonomy and acceptability to those affected by decisions. In this sense, it is related to the general principle of liberty which emphasises the freedom for people to pursue their lives as they choose. When applied to the problem of radioactive wastes, these principles sometimes reveal conflicting perspectives.

7. The way in which a given ethical principle is applied in practice will often depend on judgements from other branches of knowledge, including science. If, for example, the ethical principle of fairness between generations is prominent, what this means for option recommendations will depend heavily on scientific judgements about the degree of confidence in the long-term safety of geological disposal.

8. While ethics are important they do not provide a simple answer to the question, 'What is the best option?'. Rather, ethical considerations enable us to apply our values to the options and help us to justify our choice by appealing to our value position. It must be said that ethical judgement requires careful analysis and reasoning, not simple assertion or subjective impression.[1]

9. Ethics, then, are an integral aspect of decision making. Ethical considerations were prominent in developing CoRWM's thinking in three broad areas: environmental sustainability; intergenerational equity; and intra-generational equity.

Environmental sustainability

10. On the issue of environmental sustainability there are contrasting views. The most commonly articulated is the *anthropocentric* view which focusses on the environment as necessary for human well-being. The *ecocentric* viewpoint emphasises the intrinsic value of Nature in which humans are one species among many. It may be preferable to see these views in terms of a continuum rather than a dichotomy. However, they express different conceptions of sustainable development. Anthropocentric perspectives imply a version of sustainability stressing the efficient use of resources to support human needs and aspirations. Ecocentric views provide an interpretation which stresses the protection of environments and minimising impacts. There is a tendency to adopt an anthropocentric view when considering the impact of radioactive waste.

11. CoRWM's Guiding Principle 4 explicitly embraces 'the natural, as well as the human, environment' in its aim for sustainable development. The MCDA process identified impact on the environment as a separate criterion of assessment. During the public and stakeholder engagement process, environment was rated as one of the most important issues by Citizens' Panels, young people in the Schools Project and by the general public through the Discussion Guide (Chapter 7).

Intergenerational equity

12. Ethical concerns were a central matter in choosing the best option or options. Here the focus was on the broad area of intergenerational equity, more specifically on the question, 'How far should the present generation take responsibility for the impacts of its actions on the future?'. Two contrasting perspectives may be identified. One, expressed by a member of the ethics panel, is that 'responsibility has to extend to the reach of the impact of our actions'[1].

There is no justification for an arbitrary cut off point. An alternative view, which mixes the ethical and the pragmatic, is that we should exercise what responsibility we can whilst recognising that our capacity to do so necessarily will diminish over time. This perspective may also reflect a view that society has greater concern for the immediately following generations, in which it has both influence and interest, than for those in the far future over which it has much less control or concern. There is, thus, a contrast between the view of a continuing responsibility and that of a diminishing responsibility.

13. There are two broad alternatives for the long-term management of radioactive waste. They are, simply expressed, Deal with it Now, or Leave it until Later. These formed the basis of the Committee's ethical deliberations on its preferred options.

14. *Deal with it Now*. This position broadly reflects ethical considerations of justice arising from the belief that those who benefit should bear the burden. It emphasises the responsibility of the present generation to do what it can as soon as it can so that the transfer of burdens to following generations can be minimised. This position tends to favour geological disposal placing no reliance on the ability or willingness of future generations to deal with a problem created by the present.

15. *Leave it until Later*. By contrast, this approach emphasises the principle of liberty, providing the future with the freedom to make its own choices. This comes from a position which recognises both the rights of future generations as well as the responsibilities of the present. It is incumbent on the present to provide information and compensation to enable the future to take responsibility. This view tends to favour continuing storage options with the possibility of retrievability.

16. These contrasting ethical positions, where justice appears to conflict with liberty, were reflected in the conflict between minimising burden and increasing flexibility that became one of the most significant issues discriminating between options in the MCDA.

17. The choice between ethical perspectives and their related preference for storage or disposal is not necessarily straightforward. It must also be recognised that choices may contain elements of different ethical positions. For instance, the principle of liberty may impose burdens on succeeding generations while being concerned with ensuring justice to generations in the far future. By keeping wastes retrievable, the burden persists, but it leaves open the possibility of achieving greater confidence in the safety of disposal. The concept of phased disposal (delaying closure of the repository, see Chapter 15) represents, in effect, a way of trying to meet concerns about flexibility while also minimising burden.

18. Not surprisingly, the ethical panel argued from different ethical perspectives. There were those who favoured continuing storage on the grounds that radioactive waste should not be 'out of sight and out of mind'. It was important to maintain knowledge about potential dangers, to be able to develop new knowledge that would increase safety, to have access to potential resources and to protect future generations.

19. Phased disposal received strong support from the public and stakeholders with whom CoRWM engaged. This reflected the dilemma posed by conflicting ethical principles and the desire to keep options open for a few hundred years while providing a long term solution that reduces the burden on the present and near future generations.

20. By contrast, there is the view that we should dispose of the wastes as soon as practicable on the grounds that we cannot know what technological needs or powers may be available to our successors. The present generation should

remove the burden imposed by its actions from the future. This view ultimately prevailed among the Committee and the arguments are presented in the Overview and in Chapter 13.

Intra-generational equity

21. Ethical concerns were also an important element in the Committee's development of its proposals for implementation. The key principle here is intra-generational equity. In terms of radioactive waste, the problem is how to apply the principle to such issues as siting facilities, compensating communities and ensuring participation in decision making.

22. In terms of siting, radioactive waste facilities are necessarily unevenly distributed geographically. Intra-generational equity requires that actions should not impose an unfair or undue burden on individuals or groups within the current generation. There are different ethical considerations that are relevant in applying the broad principle to siting. Applied as a principle of justice, intra-generational equity might be interpreted in terms of: parity (sharing of the burden among places); proportionality (those who benefit take the burdens); responsibility (putting waste in places which already have it); and vulnerability (avoiding burdening such communities).

23. Viewed in terms of well-being, intra-generational equity suggests a utilitarian perspective, providing the greatest benefit to the largest number through, for example, siting facilities in areas of low population or through avoiding transportation of waste by leaving it where it is. Another approach might be to consider siting in terms of the principle of dignity, interpreted as locating facilities in those places where public acceptability can be achieved.

24. It is clearly not possible to satisfy all the possible ethical criteria that can be applied to siting. But, through its public and stakeholder engagement and in its own deliberations, CoRWM concluded that fairness in siting facilities could only be achieved by the enhancement of well-being and public acceptability based on a willingness to participate and a right to withdraw from a siting process. These principles are embodied in CoRWM's recommendations on implementation in Chapter 17 and in its report on Implementation.[2]

25. Once a community has expressed a willingness to participate, ethical issues of compensation arise. To an extent, compensation may be a condition of participation but it may be regarded as unethical to use it as an inducement. Such an approach may be seen as targeting the vulnerable. Rather, compensation should be a matter for negotiation and provided as recognition of a responsibility undertaken on behalf of society as a whole. Furthermore, compensation should not be seen in terms of financial reward, but in the broader context of regional development both now and in the future. These considerations led CoRWM to propose the establishment of partnerships between host communities and the implementing body and the provision of packages to ensure the social and economic well-being of the community.

26. Intra-generational equity also bears on the issue of participation in decision making. Here the ethical issues concern how communities are represented and who has the power to take decisions. Ethical concerns focus attention on the rights of communities to participate, on the need for broad participation and on the need for participation to be endorsed by the community. This raises the issue of how participation is made effective and how it relates to democratic decision making by elected representatives. These ethical and political considerations gave rise to much debate within CoRWM. The Committee affirmed the principle that key decisions must be ratified by appropriate democratically elected bodies. There

remained the issue of how host communities, as well as neighbouring and other communities affected by transport of radioactive waste, could secure effective representation. It is fair to say that this and other issues such as how communities are defined, how rights to withdraw are exercised and so on, have to be resolved. These issues of the relationship between participative and representative democracy are matters for further discussion during the implementation process.

New build

27. CoRWM's ethical concerns focussed on legacy wastes and those wastes within the inventory as defined in Chapter 2. During CoRWM's discussions the possibility of new build arose and led the Committee to consider the ethical concerns in relation to wastes arising from a programme of new nuclear power stations. It was suggested that an ethically sound solution for wastes arising from new build might be different from the option that might be ethically acceptable for the unavoidable wastes that were within CoRWM's remit. CoRWM subsequently issued a statement on new build (see Overview) which stressed the need for new build wastes to be separately considered. The ethical issues surrounding new build are discussed in the report of the Ethics Workshop.

Conclusion

28. Throughout its deliberations, including public and stakeholder engagement and the MCDA, ethics played a significant role in CoRWM's decision making. Ethics enable us to deepen awareness and understanding of issues and to explore what should be done and why. They form part of an overall assessment which seeks to integrate different forms of knowledge to reach conclusions that are founded in science, in values and in public trust and confidence.

References

1 Committee on Radioactive Waste Management, "Ethics and Decision-Making for Radioactive Waste", Workshop Report, document 1692, March 2006.

2 Committee on Radioactive Waste Management, "Moving forward: CoRWM's proposals for implementation", document 1703, July 2006.

Chapter 7 Involvement of citizens and stakeholders

The requirement to engage widely throughout its work was highlighted in CoRWM's terms of reference, and it was quickly identified as a critical strand of CoRWM's programme. The Committee used a suite of methods to engage with a wide range of members of the public and stakeholders (interested parties) to test and inform its thinking and decision-making at each stage of its programme, including its recommendations. As a result of this substantial engagement, CoRWM believes that its recommendations can inspire public confidence.

1. CoRWM's terms of reference clearly showed that public and stakeholder engagement, and the need to inspire public confidence, should be key elements of the Committee's work. While this would in no way eclipse the need for robust technical solutions, the way in which the terms of reference were couched showed that the Government recognises that radioactive waste is a social as well as a technical problem. This chapter shows how CoRWM involved the public and stakeholders throughout its programme to ensure the robustness of programme outcomes, as well as to lay the basis for inspiring public confidence in the final recommendations and how they were reached.

Terms of reference

2. CoRWM was required by its terms of reference to:

- Engage members of the UK public, and provide them with opportunities to express their views
- Provide opportunities for participation by key stakeholder groups with interests in radioactive waste management
- Inspire public confidence in the way in which it works, in order to secure confidence in its eventual recommendations.

Approach

3. The Committee felt that a participative, inclusive, deliberative approach to public and stakeholder engagement was necessary. It believed that to develop its work in private for subsequent peer review by a limited number of consultees was not acceptable. CoRWM therefore opted for a substantial programme of engagement involving as wide a range of different views as possible, including intensive engagement with invited participants. Recognising the ubiquity of ethics and the need to inspire public confidence, the Committee believed that those with limited prior knowledge of radioactive waste issues would have an important role to play. It was also committed to adopting a deliberative approach whenever possible, to enable values and ideas to be explored openly and through wide-ranging dialogue between participants. Every effort was made not simply to consult, but to encourage debate and exchange of views, and to enable the public and stakeholders to participate in key stages of CoRWM's assessment and decision-making processes.

The role and nature of PSE

4. CoRWM needed to ensure that its PSE programme stimulated informed debate and feedback in order to inform decision-making at key stages within the programme. The aim was not to seek to persuade participants to reach a

particular point of view nor, at the other extreme, simply to adopt what people said. Where possible, participants were encouraged to be open-minded and to weigh evidence and arguments, as the process of engagement proceeded and at key points within the programme.

5. As this was such an important strand of its work, CoRWM allocated time and resources to investigating methods of public and stakeholder engagement that might fit its purpose. In particular, the Committee placed emphasis on types of PSE activity that would provide opportunity for deliberation.[1] The trialling of 'Deliberative Mapping' early in its work has been mentioned in Chapter 5, and is described in more detail in section 1 of Annex 4. Lessons from this trial enabled the Committee to feel confident that the types of activity undertaken in the Deliberative Mapping exercise would generate useful and informative feedback.[2] A comprehensive review of methods for engaging with the public and stakeholders was undertaken,[3] and examples of previous use of some of these methods were studied such as the radioactive waste management citizens' panel organised by UK CEED.[4]

6. The time and effort put into studying what methods were available allowed CoRWM to design a PSE programme that used a variety of different methods, and involved a wide range of people. Each phase of PSE was planned to meet the aims of that phase, and the resulting mix of activities was chosen to maintain a balance between engaging with members of the public and engaging with stakeholders who have a known interest in the issue. Balance was also required between national stakeholders and local nuclear site stakeholders from different parts of the UK, and between open access events and those which were by invitation only (see Table 7.1 for further details).

PSE engagement methods

7. CoRWM wished to engage at both national and local levels, and with those who held a wide range of expertise, knowledge and views. This included those with a technical knowledge of radioactive waste, such as the regulators and industry; those with no detailed technical knowledge but a remit to uphold the well-being of society such as local councillors; those with no public appointment but with an interest in the issue, either through living in the vicinity of a nuclear facility, or through membership of an environmental pressure group; and members of the public with no prior knowledge of, or 'stake' in, radioactive waste issues. The last category could be divided into two: a small number of citizens who would be engaged with more intensively by being given time to learn about the issue and deliberate on its various aspects, and a much larger number of citizens who would be asked for their views after a basic introduction to the issues. The former category will be referred to as the intensive strand, and the latter as the extensive strand.

8. Each PSE event was tailored to the level of knowledge and expertise of the participants as well as to the information that CoRWM needed for the particular phase of the programme. Much time and effort was then put into process design to enable participants to play to their strengths. While some groups were formed at the beginning of the programme and continued with the same method of engagement throughout, for example the National Stakeholder Forum, others such as the discussion groups, were used at different stages in the programme. This approach made it possible for significant improvements to be made in successive stages of PSE by building on the experience of earlier stages. To help design and run its PSE activities, CoRWM involved a range of specialists, including The Environment Council, The Centre for the Study of Environmental Change at Lancaster University, Dialogue by Design, Public Space Ltd and Wayne Talbot Associates.

Table 7.1

Activity	Participants	Main Aims
Discussion Groups	Eight groups of 8 recruited citizens at different locations across the UK.	To elicit basic views and concerns about radioactive waste management (PSE1).
Citizens' Panels	Four panels of 12-16 citizens met three times. The panels covered Scotland, Wales, North and South England. Citizens were recruited to ensure a mix of gender, age and social class, but to avoid people who work for the nuclear industry or belong to an anti-nuclear group.	To participate in shortlisting, options assessment and review of draft recommendations (PSE2, 3 and 4).
Discussion Guide	568 self-selecting groups from across the UK, including community groups, environmental groups, older people and schools	To discuss issues relevant to the assessment of shortlisted options and provide feedback (PSE3).
Schools Project	1305 students (aged 11-18) from 15 schools in Bedfordshire.	To identify and discuss the issues considered important to the assessment of options and provide feedback (PSE3).
National Stakeholder Forum	20-25 participants from national bodies, including Government Departments, Non-Departmental Public Bodies, the nuclear industry, the regulators, local government and campaigning groups. The NSF met four times.	To participate in shortlisting, options assessment and review of draft recommendations (PSE1, 2, 3 and 4).
Nuclear Site Stakeholder Round Tables	Meetings in eight locations for stakeholders from local organisations around a total of 14 nuclear sites (covering civil and military, public and private sector and different types of facilities). The RTs met three times, with a fourth round of events for nominees from each area.	To participate in shortlisting, options assessment and review of draft recommendations (PSE1, 2, 3 and 4).
Open Meetings	Two rounds of open meetings were held in eight areas close to nuclear sites.	To identify views and concerns about radioactive waste management, including shortlisting (PSE1 and 2).
'Bilateral' Meetings	A series of meetings between CoRWM members and representatives from stakeholder organisations.	To obtain information and discuss issues as appropriate to the aims of each period of PSE.
Consultation Documents	Various stakeholders and members of the public	To seek views on a formal consultation document over a three month period (PSE1 and 2).
Web-based	Various stakeholders and members of the public.	To provide opportunity for comment on consultation papers, specialist judgements of option performance, and draft recommendations (PSE1, 2, 3 and 4).

9. Thought was given to the number of events of each type, the representation of different viewpoints, and the numbers attending each event. Table 7.1 provides an overview of each type of event and the main aims of engagement.

The PSE programme

10. While few of the methods used by CoRWM were particularly innovative when considered alone, the combination of such a wide range of activities, involving both stakeholders and members of the public, across four periods of time, was distinctive and novel. The PSE periods were timed to provide the necessary input to allow the Committee to proceed with its programme.

11. Time pressures meant that it was not always possible to await the full results from engagement activities before starting to plan subsequent phases, but no decisions that were dependent on PSE feedback were ratified until full consideration had been given to the views expressed. The four phases of engagement were:

    - PSE 1 (November 2004 – January 2005)

      To seek views on the inventory of radioactive wastes and materials, a long list of long-term radioactive waste management options and the criteria that should be used to screen out options.

    - PSE 2 (April 2005 – June 2005)

      To seek views on the proposed shortlist of management options, the criteria that should be used to assess them, participatory processes for options assessment, and implementation issues.

    - PSE 3 (October 2005 – February 2006)

      To enable participation in the assessment of shortlisted options, including the expression of views on the importance of different criteria, on specialist judgements of option performance (‘scores’), and preferences for long-term management options.

    - PSE4 (May 2006)

      To seek comments on CoRWM’s draft recommendations, including proposals on how they should be implemented, and ways of increasing public confidence.

12. Dividing the PSE programme into successive stages had many advantages. It provided an opportunity to deliberate on feedback so that decisions on substantive issues, and on programme design, were informed by public and stakeholder views. It also enabled the Committee to apply learning about processes of engagement to subsequent PSE activities. Participants were able to weigh evidence and arguments through a sustained programme of engagement, and there was no doubt that it helped to build confidence and trust among participants.

13. These activities produced significant feedback to inform CoRWM’s programme at critical stages. CoRWM members did not just rely on the reports of the events, but placed great importance on attending PSE events so that they could hear for themselves the views and arguments that were being expressed.

Involvement of stakeholders

14. CoRWM used tried and tested methods of engaging with stakeholders, and put a great deal of thought into the breadth and depth of participation required. It saw the National Stakeholder Forum as a sounding board consisting of all the major sectors with an interest in the issue at a national level. These sectors were UK Government and the devolved administrations, non-departmental public bodies, regulators, the nuclear industry, and non-governmental organisations. The Committee recognised that representatives from many of those sectors at a local level would bring a different perspective, and that there were also other sectors that should be included at that level. These additional sectors were community representatives and local Government.

15. Time and resources did not allow stakeholders from all nuclear sites to be included, so the programme of local nuclear site round tables was based on events held at eight locations which were judged to maximise the number of sites represented (14) and covered civil and military, public and private, and different types of facility. Many of the earlier discussions at these events utilised mixed stakeholder groups (mixing the sectors) giving the benefit of cross-fertilisation of views and ideas. When specific sector views were required, break-out groups were formed by sector. By giving careful consideration to the input that CoRWM needed at each stage, stakeholder events were designed to maximise the value of bringing together a good cross section of stakeholders from a range of sites.

Involvement of citizens

16. During the first period of PSE (PSE1), CoRWM was interested in the general values that people with limited prior knowledge of radioactive waste applied to the problem. It therefore organised a series of discussion groups. A recruitment firm was contracted to recruit 64 citizens, from various parts of the UK, with a good mix of age, gender and social class. Eight groups of eight citizens were asked to discuss, in two meetings each of two hours, their general views and thoughts about what was important when considering radioactive waste, having been sent a leaflet about the issue, and been given some basic facts during the discussion. A particular aim was to assess how citizens might be involved in later stages of the programme.

17. Many of the discussion group participants had barely heard of radioactive waste before. Yet by the end of the second session they were commenting on CoRWM's long list of options, and the criteria by which they should be assessed. Most said that they would have liked more information, particularly technical information, and that they would be happy to remain involved in the CoRWM process. While this did not prove possible, the major lesson that had been learned in the Deliberative Mapping trial, that citizens are well able to engage in radioactive waste issues, was reinforced. A theme that was to continue throughout the CoRWM PSE process was that the discussions had been stimulating and informative, and that CoRWM should recommend more education on the issue in schools as well as measures to increase public awareness.

18. During PSE1, a series of Open Meetings was also held near existing nuclear sites around the country. These were aimed at citizens living close to nuclear sites who were not invited to stakeholder events, but who, CoRWM believed, would wish to have an input into the Committee's deliberations. A second round of Open Meetings at the same locations was held in PSE2. While much of the time in these meetings was spent answering questions, CoRWM members obtained useful information on the views of people living with the reality of nuclear activity close to their homes.

19. Largely as a result of what was learned in both the Deliberative Mapping trial, and in PSE1, CoRWM put in place plans to involve citizens in the substantive options assessment phase of its work. There was a desire to elicit two main types of view: what citizens feel once they have developed a reasonable level of understanding of the issues and had time to deliberate on them, and how citizens respond when just provided with basic information and a relatively short time to discuss the issues. There was also recognition of the very long term nature of radioactive waste, and its potential impact on future generations. The Committee was therefore interested in the views of the younger generation, in particular whether their values and ethical stance differed from those of their parents and grandparents.

20. The main method of intensive engagement with citizens was through Citizens' Panels. Four panels each of between 12 and 16 citizens of mixed age, gender and social class were recruited, one each in Scotland and Wales, and one each in the north and south of England. The Committee was advised that although this could not be claimed to be representative in the statistical sense, the numbers and geographical spread were sufficient to provide a good understanding of the range of views that would exist among the general public. While much of the first round of panels necessarily involved briefing and initial discussions about radioactive waste, CoRWM was also seeking views on what people felt was important when considering a difficult socio-technical issue. This included the elicitation of criteria that the citizens felt that CoRWM should use when assessing its options. The second round of panels included an opportunity for the participants to question specialists about technical and ethical aspects. For each panel CoRWM recruited four or five specialists representing a range of views on the issues being put to the panels, and citizens heard short presentations and questioned the specialists intensively over the course of a day. Several of the specialists commented on the high quality of the debate. The citizens then participated in elements of the assessment process itself. They engaged in substantive deliberation, and the quality of the discussions and output was high. This was particularly noticeable in the third round of panels when participants were asked to discuss some of the more difficult ethical issues in the context of technical solutions.

21. The intensive form of engagement with young people was in the form of a project run in 15 schools in Bedfordshire during PSE3. Participants were initially taught the basics of the issue, and were asked to research the answer to some questions. Having fed back what they learned, they then devised a method of consulting their peers on the relative importance of CoRWM's criteria for assessing waste management options. This involved a much wider group of students, allowing over 1300 young people to provide their views. The penultimate stage was an assessment by the original participants of the relative importance of the criteria. Members from all 15 schools then had the opportunity to report their findings at a combined conference during which CoRWM members led discussions on particular issues. Again, the quality of the discussion was high, and the ability of the young people to provide a top level view on which waste management option they favoured, and to justify that view, was impressive.

22. The extensive engagement with citizens and young people was primarily based on use of a Discussion Guide in PSE3.[5] The aim was to enable many more people to discuss the issue, and provide their views to CoRWM. The discussion guide consisted of basic information about the radioactive waste issue in a readily usable form along with some simple questions to prompt and guide the discussion. The main topics for discussion were the relative importance of CoRWM's assessment criteria, views on ethical issues, and an opportunity to provide a view on their preferred long term management option. The guide was given as much publicity as possible, inviting already formed groups of people such as local environmental groups, church groups, and women's institutes, to spend an hour or so discussing the issues and answering the questions. The feedback from the 568

groups who provided a response was analysed, and a website was set up for participants to see the results. A significant number of those who participated were school groups, the results of which were analysed separately to give the views of young people.

23. In addition to these activities, in both PSE1 and PSE2, CoRWM put together a formal consultation document[6] supported by information leaflets laying out the background and asking specific questions. These were available on the CoRWM website, with the facility in PSE2 for an electronic response. They were also sent to between 4000 and 5000 people who had previously expressed an interest in radioactive waste to Defra. Responses were received from a wide range of stakeholders and members of the public, and were analysed in 'written and website' response reports.

24. CoRWM has been asked how people with little or no knowledge about radioactive waste issues can provide input into such a complex technical issue. It is worth reiterating that great care was taken to involve each group of participants in ways that were appropriate. The level of question, and the topics, were carefully chosen so that meaningful and useful responses were received. People were asked specific questions that involved them using their existing experience, knowledge and values to make judgements within their competence, and the resulting data were used in appropriate ways.

How the PSE process influenced CoRWM's decisions and recommendations

25. CoRWM members are clear that the public and stakeholders have had a very significant influence on their work from the time of the first consultation (PSE1) to the formulation of the recommendations (PSE4). A vast amount of feedback has been analysed, and each period of PSE has been formally reported, with all reports published on CoRWM's website.[7] It is impossible to reflect all the ways in which CoRWM took people's views into account, but the following gives a brief outline of the main ways in which CoRWM's decisions and recommendations have been influenced by PSE.

The Inventory

26. The feedback from PSE1 on CoRWM's draft inventory report[8] was used to inform the development of a revised report[9] In response to comments, the new version contained, for example, more information on the suitability of some ILW waste streams for near surface disposal and a wider range of scenarios exploring the impact of different energy futures. Even at this early stage, and continuing throughout CoRWM's engagement process, some participants encouraged CoRWM to address the issue of new nuclear power, and also whether plutonium, uranium and spent fuel should be declared as waste, both issues that strictly lie outside CoRWM's remit. Later chapters show how the Committee has responded to these requests.

The long list of options

27. The main messages from PSE1 were that CoRWM's proposed long-list included all the main categories of options and that they were sufficiently characterised.[10] CoRWM concluded that suggestions for specific examples and variants could be accommodated within its future assessment of short-listed options.[11] It also clarified the meaning of 'indefinite storage', which it renamed 'storage forever'. PSE1 participants also pointed out that some options on the list – for example incineration, melting, and use in reactors – should be seen as processes rather than end points. As a result, these sorts of options were not carried forward on to CoRWM's shortlist of options. While there were a few respondents who felt that

CoRWM had included too many 'unlikely' options on its long list, the majority supported the need for a thorough, root and branch, review.

Screening criteria

28. During PSE1 CoRWM's proposed screening criteria were broadly supported, but some were criticised for lack of precision.[12] A small number of additional criteria were proposed. CoRWM's response was to provide improved definitions of the criteria and to add a tenth criterion about whether an option should be implemented abroad if it were feasible to implement it in the UK.[13] It also decided to take comments about other potential criteria into account in developing criteria for use in assessment of short-listed options.

The shortlist

29. The feedback from PSE2 showed that there was widespread support among participants for the proposed shortlist, in the sense that it contained those options that should be carried forward for detailed assessment.[14] A range of comments and suggestions was also made on potential additions and deletions from the list, on potential 'watching brief' options, and on the options themselves. CoRWM reviewed these comments when finalising its short-list.[15] As a result of PSE2, the Committee was able to take decisions on the shortlist, confident that it had not excluded any options that had widespread support. It also indicated that it would return to the issue of 'watching brief' options in its final recommendations (see recommendation 5 on research and development in Chapter 14). Further details on the shortlisting process can be found in Chapter 10.

Assessment criteria

30. In PSE2 CoRWM asked for comments on the criteria that it proposed to use to assess the shortlisted options.[16] The feedback showed that there was broad support for the proposed assessment criteria.[17] There were however a large number of comments, including suggestions for additional criteria and ways of applying criteria. These comments were taken into account as CoRWM developed its thinking on the criteria and sub-criteria that would be used in options assessment[18] (see Section 2 of Annex 4).

Participatory processes for options assessment

31. CoRWM's proposals for options assessment and the ways in which people might be involved were also discussed in PSE2. Some reservations were expressed about MCDA, but the method also received significant support. There was strong support for the use of a second assessment method running in parallel to the MCDA. The principle of participation was embraced enthusiastically by the majority of participants,[19] with those involved in nuclear site round tables being particularly keen to meet again and for longer if possible. Citizens' Panel participants also felt strongly that they had an important role to play and should have an ongoing involvement throughout the process. They specifically asked to be given access to specialists before any involvement in the assessment process. Almost the whole of the first day of the second panel was therefore devoted to interaction with specialists. Participants in events, and respondents to the consultation document, provided suggestions on broadening public participation, placing particular emphasis on the need to engage with young people which was already being planned. Some also requested the opportunity for a formal organisational response which was provided through bilateral meetings and written submissions. There was widespread agreement that the options assessment process must be conducted in an open and transparent way, which led CoRWM to conduct its MCDA in public. These, and many other comments,

helped shape CoRWM's planning for options assessment,[20] and the process that was ultimately used is outlined in Chapter 11.

Ethical issues

32. Discussion of the ethical issues associated with the management of radioactive wastes was an important component of activities in PSE2 and PSE3, but they inevitably pervaded all phases of PSE. During PSE2 a series of ethical questions were posed to stimulate discussion.[21] The feedback from this discussion [22] helped inform CoRWM's workshop on ethics.[23] The output from the workshop was then fed into CoRWM's options assessment.[24] During PSE3, ethical issues were inherent in making judgements on the importance of criteria, and were a specific element for discussion in some events. CoRWM members paid particular attention to the ethical positions held by participants, and observed how those values influenced their thinking and judgements. The way in which CoRWM tackled ethical issues is described in Chapter 6.

Implementation issues

33. Discussion about the issues involved in implementing long-term management options was also started in PSE2.[25] The findings from these discussions[26] were used to inform the preparation of a paper for CoRWM's workshop on implementation issues. The output from this workshop[27] provided the basis for CoRWM's recommendations on implementation issues. The public, members of existing partnerships, regulatory authorities and many other organisations such as local authorities, trade unions, community councils and NGOs have played a key role in shaping how CoRWM's recommendations could be implemented. Details of their contributions are contained in outline in Chapter 17, and in more detail in the accompanying Implementation Report.

Criteria weighting

34. A major part of PSE3 focussed on enabling participants to express views on the relative importance of the different assessment criteria. Five types of PSE activity generated criteria weights - use of the Discussion Guide, the Schools Project, the Citizens' Panels, the Nuclear Site Stakeholder Round Tables and the National Stakeholder Forum. The findings were collated and summarised for use in CoRWM's MCDA,[28]. The report of CoRWM's MCDA explains how the findings were used in sensitivity testing,[29] and section 5 of Annex 4 gives a brief outline. The results from the Citizens' Panels, Discussion Guide and Schools Project showed a remarkable amount of broad consistency, although it was noticeable that the latter two placed lower importance on 'burden on future generations' and 'flexibility'. This may have been because they had less opportunity to deliberate on these issues; an example, perhaps, of the value of intensive engagement and deliberation. There was more variation in weights from the stakeholder meetings due to the various sectors represented at each event, but it was possible to detect trends within each sector. CoRWM members used these outputs in two ways. First, to inform their own judgements as they undertook the weighting of criteria in the MCDA, and second, to investigate the impact of varying the weights on the model outputs in sensitivity testing. The feedback from PSE was used to identify the outer limits of variation of those weights. Further details can be found in Chapter 11.

Specialist judgements of option performance

35. PSE3 provided opportunity for participants to comment on the scores that specialists had given to the options against the criteria. While many of these scores were based on a high level of technical knowledge, some also involved

ethical judgements. These comments were made at stakeholder events and through a web-based opportunity to comment. A relatively small number of specific changed values for scores was suggested, but from the comments received it was possible to make a judgement on an appropriate revised score. These revised scores were then used to conduct specific sensitivity tests on the scores[30] during the MCDA.[31]

Preferences for long-term management options

36. Participants in PSE3 were also encouraged to express views on which of CoRWM's shortlisted management options they preferred. There was a desire from stakeholders to establish a policy on long-term management as soon as possible, but there was divergence between the majority who felt that this meant geological disposal and a smaller number who preferred continued storage. The Citizens' Panels made their assessment after a discussion on the ethical dimensions of the issue,[32] clearly favouring forms of geological disposal. The Schools Project delivered an almost unanimous vote for geological disposal, which was also favoured by a large majority of those using the discussion guide. The findings from the Panels, and from other PSE3 activities, were collated into an overview report[33] that was then used by Committee members when they conducted their own holistic assessment.[34]

Draft recommendations (PSE4)

37. The main purpose of the fourth round of public and stakeholder engagement was to seek views on CoRWM's draft recommendations, and how public confidence might be increased. Although limited time was available, the NSF held its fourth meeting, the nuclear site round tables sent participants to combined meetings in either London or Glasgow, participants from the Citizens' Panels met in London and Glasgow, a number of bilateral meetings were held, and around 100 responses were received via the website. The great majority of participants and respondents were very supportive of the draft recommendations.

Conclusion

38. It is not possible for everyone in the country to be involved in an engagement process, nor would they wish to be. Within the time and resource constraints under which CoRWM operated, the large number (5000 or so) of people who have been involved is indicative of the efforts made to develop a substantive public and stakeholder programme. Many PSE participant and specialists have commended CoRWM for its attempts to be as inclusive of all views and opinions as possible.

39. CoRWM has listened to what the public and stakeholders have said, has discussed the implications in open plenary meetings, and has sought to explain the basis for its subsequent decisions. The fundamental role of the public and stakeholders in the four periods of PSE has been to help shape the formulation of CoRWM's recommendations by influencing both CoRWM's programme and its assessment process. A key feature has been the attempt to integrate the views of the public with the views of those having specialist knowledge. The mutual learning that this has provided has done a great deal to build confidence in CoRWM's recommendations.

40. Based on its direct experience of engaging with the public and stakeholders, CoRWM believes that its recommendations can inspire public confidence.

'CoRWM's PSE programme is the most elaborate and extensive to have been carried out for this kind of policy issue … Overall, CoRWM has attempted to adopt a highly reflective approach to its task, scrutinizing its own assumptions and methods to an extent that contrasts markedly with the technocratic approach taken in the past.'[35]

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Chapter 8 CoRWM and science

CoRWM recognised from the outset that its recommendations have to be scientifically and technically robust if they are to withstand challenge during implementation. The science strategy adopted was to use the best available scientific knowledge at appropriate stages of the CoRWM process.

The science strategy

1. CoRWM was deliberately established with a broadly based membership to consider a range of issues, including scientific, technical, ethical, legal, economic, and social ones. It was not set up as a traditional scientific committee. While several CoRWM members have relevant scientific expertise, the Committee always recognised that it essentially had an oversight role and would need to bring in relevant expert knowledge, as and when required.

2. There was insufficient time in the programme to commission new original research. It was decided that if unresolved scientific issues remained, any need for new research could be included in the recommendations of the Committee. The process of implementation will in any event require active research and development and the site evaluation stage will need much detailed scientific work.

3. The basic premise was to use the best available existing scientific knowledge. This was drawn together, firstly through literature review, in a series of documents at various stages of the programme by a number of specialist consultants. A 'peer review' panel from academia, industry and the regulators was established to assist with the technical review of documents and work packages. The quality of the papers was variable, but the Committee had access to peer review comments to assist in their judgements. For the later stages in the CoRWM programme, particularly the option assessment phase, CoRWM established panels of scientific specialists to bring together the latest relevant scientific opinion. Each person was appointed for their individual knowledge and expertise in the disciplines relevant to CoRWM's assessment criteria.

4. In the early stages of CoRWM's work, the main focus was on developing an inclusive and innovative public and stakeholder engagement programme. CoRWM was always clear that science was going to play a key role in its work, but this was not fully articulated in these early stages. This led to some criticism[1] which the Committee subsequently sought to address. The early scientific input to CoRWM related mainly to the inventory and this is detailed in Chapter 2. A more substantial input came in support of the shortlisting process and helped justify the selection of the management options taken forward for full assessment. The bulk of the scientific input came in respect of the option assessment processes and in particular the specialist judgement of option performance for the MCDA. At each stage of CoRWM's work, the level of detail entered into was designed to be sufficient for the task in hand. Sporadic criticisms as to the comprehensiveness of the scientific programme continued but following a subsequent joint meeting of the House of Lords Science and Technology Committee and the House of Commons Environment Food and Rural Affairs (EFRA) Select Committee, the House of Lords was encouraged by CoRWM's emphasis on scientific and technological input.[2]

5. In order to ensure the scientific strategy was sufficient, Defra's Chief Scientific Advisor, Professor Howard Dalton FRS, set up a specialist panel to advise him. Members of this panel have advised CoRWM on the quality assurance and peer review processes, and the membership and scope of the specialist panels.

6. Since science would play a vital role at several stages of the programme if the recommendations were to gain public and stakeholder confidence, CoRWM instigated, through its Information Working Group, a process to gather and assess information early on in its programme. This drew on the considerable amount of international and UK research into the long term management of radioactive waste that has been conducted for many years. The Working Group also considered previous work commissioned by Defra[3] to identify the status of information on radioactive waste management and then commissioned work by external specialists to fill any gaps identified.

Initial review of the science of radioactive waste management

7. The position with respect to the science of underground radioactive waste disposal to the end of the 1990s appears in the review of the Parliamentary Office of Science and Technology in 1997.[4] In particular this considered the uncertainties in the science that contributed to the failure of the Nirex RCF planning application.

8. The review outlined previous work of the Royal Society[5] involving analysis of the science involved in repository (post closure) performance assessment. Such assessments cover characterising the rocks and geological regions around a repository (the geosphere); modelling chemical changes during radioactive decay; modelling of radionuclide transfer to the geosphere; modelling radionuclide movements into the wider geological environment; and understanding the behaviour of radionuclides in the biosphere (in the soils, seas, rivers, atmosphere, etc) and thus their impact on man.

9. The POST report also discussed uncertainties relating both to the inherent unpredictability of future events and the mathematical modelling of the various transfer processes listed above.

10. Despite the uncertainties, the Nuclear Energy Agency (NEA), the agency of the Organisation for Economic Cooperation and Development (OECD) responsible for promoting nuclear energy, stated that ‘there is a high level of confidence among the scientific and technical community engaged in waste disposal that geological disposal is technically safe’.[6] However, it also noted that ‘the common perception amongst the public that there is a strong body of technical opinion challenging the feasibility of safe disposal does not reflect the reality of the debate. The number of sceptics is relatively small in the broader technical community, whereas there is a wide consensus of the safety and benefits of geologic disposal within the technical community of waste management experts.[6]

11. The NEA also expressed the view that there had been significant progress in relevant scientific understanding and in the technology required for geological disposal in the ten years up to 1999.[7] This included a deeper scientific understanding of the processes which determine the effectiveness of repositories in isolating the waste over long periods; improved characterisation and quantitative evaluation of the ways in which the engineered barriers and surrounding rock contribute to safety; and also experience with practical aspects of underground engineering and implementation.

Information on the inventory

12. In the identification of potential wastes in the early stages of the programme, the Committee drew on the scientific and technical expertise of waste producers, managers, regulators and environmental groups. The robustness of their data and conclusions was tested, among other ways, by seeking comments from other specialists and organisations (see Chapter 2).

Shortlisting process

13. The short-listing process involved the critical review of the long list of options. As part of this review CoRWM commissioned summary technical briefing papers to bring the committee up to date with recent developments affecting the range of options potentially available, including some of the more unconventional options, such as disposal in space and in ice sheets[8 9]. In particular the papers considered the findings of recent safety assessments in the UK[10] and in overseas countries developing forms of geological disposal – Sweden,[11 12] Finland,[13] Switzerland[14 15] and France,[16] as well as other programmes[17 18 19] and the uncertainties associated with the science.[20 21]

14. CoRWM also reviewed other UK and international knowledge and experience of the long list of options. In-depth science was not required at this stage, only sufficient information to discriminate between options and eliminate non-viable ones. Time constraints prevented the pursuit of a conventional scientific 'peer review' process in this stage of work but the extensive feedback CoRWM members received on the scientific work showed it to be fit for purpose. At the end of the short-listing process, experts, stakeholders and the public agreed, with very few exceptions, that the CoRWM shortlist was appropriate and reasonable.

The specialist panels

15. As reported in Chapter 11 the options assessment process involved evaluating the performance of the various shortlisted options against 27 different performance criteria. Many of these assessments required robust scientific and technical judgments to be made, for example on worker and public radiation exposure, security issues and environmental performance.

16. CoRWM established seven specialist (or expert) panels appropriate to the disciplines required by the assessment criteria. Advice on the composition of the panels was provided, among others, by eminent independent academics on CoRWM's Quality Assurance group and the Defra Chief Scientific Advisor's panel. Around 70 specialists were involved and they gave appropriate, effective representation across disciplines. As an example, the health and safety panel included expertise at internationally recognised senior academic level on radiation effects, health and safety, radiation protection, regulation, engineering, geology, geochemistry, hydrogeology and transport. Efforts to involve scientists from the environmental groups – particularly in the 'safety' area - were hampered by limited availability of the comparatively small number of experts the NGOs have to field. However, some of the independent specialists who had carried out work for the environmental groups in the past offered a critical perspective during the panel sessions.

17. The specialists met initially to develop performance scoring schemes and determine any outstanding information needs. Work was commissioned to provide the necessary information and briefing papers were written to support the scoring workshops. The allocation of option scores against criteria was typically undertaken in open forum where the specialists' judgements were discussed in front of approximately 10 other specialists, CoRWM Members and scientific observers and consensus sought.[22] Members of Professor Dalton's panel attended many of the workshop sessions.

18. As background material for the initial specialist workshops on safety, two papers were commissioned, one from IDM[23] and the other from Enviros.[24] These included reviews of the safety of geological disposal[25] and highlighted areas of disputed knowledge including the debate on dose-risk relationships.[23]

Other events reviewing the safety of geological disposal

19. CoRWM also invited individual specialists to attend Plenary workshops[26] at which critically important areas of the long term safety of geological disposal and the issues associated with storage were discussed. These debates provided important information when CoRWM evaluated its options through the holistic assessment method and integrated the knowledge from other areas of work.

The Royal Society

20. The Committee has benefited from support from the Royal Society, during its work. The Royal Society hosted a meeting on 7 November 2005 chaired by Professor Geoffrey Boulton, FRS (an independent member of CoRWM's QA group). Fellows, whose expertise ranged across science and engineering, discussed key issues relating to CoRWM's use of science and the shortlisted options. Their advice was taken into account in the later stages of the specialist workshops and in planning the later engagement with the scientific community. In particular, the Committee invited comment on the performance scoring results from the scientific and engineering community and others, to test the results of the scoring process, and several hundred people and organisations responded (see Chapter 11).

21. The Royal Society in the report of the seminar in November 2005 made the following recommendation to CoRWM: 'The confidence that could be placed in geological disposal in UK sites has been understated. A criterion for site selection should be the capacity to demonstrate, from geological evidence, the stability and integrity of the site over a past timescale significantly greater than the required isolation periods of wastes to be disposed'.[27]

22. It based this statement on the observation that 'The geological structure of many parts of Britain has been stable for very long periods of geological time and is likely to remain so into the distant future. Seismic events, and chemical, mechanical and physical changes on the Earth's surface are attenuated at greater depths. They pose a greater risk to surface stores than to deep repositories. Many deep geological environments are extremely stable with regard to surface climate change - the most likely cause of environmental instability in the UK over a timescale of tens to hundreds of thousands of years. Studies have identified sedimentary rocks whose internal physio-chemical conditions have been stable for many millions of years. Wastes emplaced in such formations would remain undisturbed over these time periods into the future and the hydro-chemical processes that could lead to radionuclides being mobilised through them take place at extremely slow rates, such that it would take millions of years to move into surrounding rock formations. The movement of groundwater is potentially an important means of transporting radionuclides towards the surface. However, the use of geochemical tracers makes it possible to reconstruct the history of past groundwater movement, or lack of it, and can provide a powerful baseline for forecasting its behaviour in the future'.

The Geological Society

23. In 1999 The Geological Society gave its verdict that 'only deep geological disposal can provide a long-term, safe and sustainable solution for radioactive waste' in a statement following a joint meeting of the Geological Society and British Geological Survey in 1999.[28]

24. The Geological Society hosted an international meeting on radioactive waste management on 9 January 2006 'Geosciences and the Long-term Management of Radioactive Waste', and this came essentially to the same conclusion. In

particular a paper by Chapman and Curtis[29] at that meeting took as a major theme the aim of the containment system to prevent the return of radioactivity until such a time that radioactive decay has reduced the activity to a similar level to that which exists naturally in the environment (a 'back to nature cross-over time'). It suggested, for example, that in respect of spent fuel (which contains some very long-lived radionuclides), around 300,000 years would have to pass until radioactive decay would be sufficient for the activity of the fuel to return to that of the natural uranium ore from which it was originally produced. At that point in the future, the hazard posed would be broadly similar to that from natural uranium. High level waste, from which uranium and plutonium has been removed, has less contribution from long lived radionuclides in the far future, so the 'back to nature' time is reduced from a few hundred thousand years to a few thousand.

25. Participants at the meeting noted how relatively little account has been taken of data from natural analogues, for example the near-surface uranium deposit at Cigar Lake in Canada and that at Oklo in Gabon. In the very long geological past, the latter site (often called a "natural nuclear reactor") appears to have experienced a natural thermal critical event. The resulting fission products and the existing uranium nuclides only migrated a few tens of metres through the surrounding rock in 2000 million years.[30]

Other Views on the Science of Radioactive Waste Disposal

26. The House of Lords Select Committee on Science and Technology took evidence from regulators, nuclear industry, and environmental groups[31]. Their Lordships found that the majority view from the scientific and technical community was that wastes should be emplaced in deep geological repositories. They also noted that the Radioactive Waste Management Advisory Committee[32] (RWMAC) advised Government to reaffirm a policy of deep disposal. The minority view, held particularly by members of environmental 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.

27. The responses to CoRWM's stakeholder engagement show the general position to be unchanged.[33] The Environment Agency welcomed "the central recommendation from CoRWM that geological disposal of long-lived radioactive waste is the best available approach. We believe this is a sustainable solution to the long term management of the waste".[33] The Scottish Environment Protection Agency (SEPA), which possesses similar statutory powers, indicated the recommendations provided a clear basis from which the Government would be able to update policy on higher activity waste.[33]

28. A response to PSE4 from the Health Protection Agency stated: ' ...any disposal of radioactive waste should meet the radiation protection criteria of optimising exposures below the relevant dose and risk criteria. HPA considers that CoRWM's choice of geological disposal as the long term management option could be implemented to satisfy these radiation protection criteria.[33]

29. The environmental groups take a different position. For example, Greenpeace considers that 'deep disposal is not a solution for the UK's nuclear waste because leaking radioactive wastes from a deep nuclear waste dump will inevitably contaminate the environment and pose a persistent, irreversible threat to future generations. The overwhelming weight of evidence is that this threat is poorly predictable, impossible to assess with current scientific understanding and likely to remain so for an indefinite period, despite many decades of expensive scientific research.[34]

Review of use of science

30. CoRWM invited a number of senior external scientists and engineers, including members of Professor Dalton's panel, to a one-day meeting to review CoRWM's use of science. The review was conducted on a non-attributable basis and although a full note was taken, this is not a public document. A short summary note[35] is available. The conclusion was that the work carried out by CoRWM appeared to be fit for the purpose of the recommendations and the accompanying Report.

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Chapter 9 Learning from overseas

International experience has played a major role in developing CoRWM's understanding of the options, the method used to assess them, and CoRWM's recommendations on implementing policy.

Understanding the options

1. It became apparent early on that all countries with a nuclear power programme that have made decisions about long term management of radioactive waste have adopted a strategy of interim storage followed by geological disposal, although the Netherlands has decided to postpone disposal for at least 100 years.[1] Recently, both Canada and France have adopted a policy of interim storage followed by geological disposal.[2]

2. CoRWM's terms of reference required a review of options for managing solid radioactive waste in the UK, starting effectively with a blank sheet of paper. In order to assess the shortlisted options against specific criteria, as described in Chapter 11, examples of each generic option had to be considered.[3] Nirex has been developing repository concepts for ILW for several decades, but nearly all the development of concepts for the disposal of HLW and spent fuel has been done overseas. The Swedish concept for the disposal of spent fuel was chosen to be the main example, because development work has been carried out for several decades and it is the concept that is likely to be operational first. When considering details, such as the ease with which the waste can be retrieved, other concepts were also considered, such as the Cavern Retrievable (CARE) concept (see Chapter 15 and report of specialist workshops[4]). This concept is being developed in Japan.

3. When considering the options for the management of short-lived ILW from nuclear reactors, one option was the shallow cavern design that has been constructed in Sweden and at both the reactor sites in Finland.

4. The options for central storage of the waste were based on the concept of the long-term national store that has been built in the Netherlands and on the national interim store for spent fuel in Sweden. For the detailed assessment, the base case was the modern store for spent fuel at Cadarache in France.

5. All members had the opportunity to visit Sweden and Finland to gain first-hand knowledge of the progress in disposing of spent nuclear fuel, the central facility for the storage of fuel and the repositories for reactor waste and the process that was used to implement a repository for spent fuel in these countries.[5] Some members have also visited the repositories for long-lived waste at Gorleben and Konrad in Germany and the proposed site at Bure in France, the repositories for short-lived waste at Cap de la Hague in France and El Cabril in Spain and the national store in the Netherlands. This information was fed into various plenary meetings to inform members.[6]

Assessing the options

6. A major input into the assessment of the options was how other countries had developed their strategies[1]. Some members had previously carried out research in this area and use was made of the considerable amount of literature that is available, such as the European Commission COMPAS project, which reviews the bases for the strategies that have been adopted in the European Union.[7] Members

have also attended the OECD Nuclear Energy Agency sponsored group of 'Chairs of National Advisory Bodies to Government', on which the overseeing bodies for France, Germany, Japan, Sweden, Switzerland and the USA are represented. Overall, this experience influenced the development of the original long list of options, the criteria that were used for shortlisting as well as the detailed evaluation of the shortlisted options.

7. The method that was used to assess the shortlisted options (see Chapter 11) was developed as a result of a review of experience worldwide and the one that was used was developed from the Co-operative Discourse Model.[8] The selection of the method to evaluate the options against individual criteria was done in consultation with experts from Germany and Canada,[9] where a major evaluation of options for the management of spent fuel was completed in 2005.[10] The Committee has had several meetings with the Nuclear Waste Management Organization of Canada, which performed this review. This Canadian experience informed CoRWM's approach to assessing the options and the principles that should be adopted when the recommendations are implemented.

8. The factors that influenced the development of strategies overseas were taken into account in developing the criteria against which the shortlisted options were assessed.

9. Many of the specialists who assessed the technical performance of the options have considerable experience in working on the long-term waste management of waste in Japan, the USA and several European countries, and several travelled to the UK to participate. The French research into disposal and storage over the last 15 years has been an important source of information.[11] A member of the Dutch Environment Ministry with responsibility for radioactive waste explained, at a plenary meeting, the reasons why the Netherlands has adopted a strategy of delayed implementation of geological disposal following 100 years of storage, when all other countries with a nuclear power programme have adopted a strategy of implementing geological disposal as soon as practicable. The factors behind the Dutch decision appear to be public acceptability, cost and the relatively small volumes of waste that have to be managed.

10. Overseas experience has been an essential input to the evaluation of the timescale for implementing a repository in the UK.

Implementing the recommendations

11. Japan, the USA and all the countries of western Europe which have a civil nuclear power programme, have experienced severe setbacks in implementing repositories for radioactive waste. Most of these countries have analysed the reasons for past failures and are moving forward with new programmes for siting a repository.

12. Some CoRWM members took part in the European Commission COWAM 2 (Community Waste Management) project, which evaluated past experience in implementing waste management projects and developed guidelines for successful implementation in the future.[12] The parallel CARL project (see Glossary) was also monitored. One member took part in a discussion on long-term criteria for the disposal of spent fuel and long-lived radioactive waste at an NEA regulators forum.

13. At several plenary meetings, the progress that has been achieved in Belgium, Canada, France and Germany was reviewed, as well as that in Scandinavia, and the sociopolitical context in each of these countries was evaluated and compared with that in the UK. This has enabled the important principles that are necessary

to ensure the successful implementation of the recommended options to be identified (see Chapter 17).

Conclusion

14. Knowledge of international experience has contributed greatly to CoRWM's work. It has shown that, outside the UK, all countries with a nuclear power programme have selected interim storage followed by geological disposal as their strategy for managing long-lived waste,[1] and that the past practice of deciding where repositories should be built without an extensive engagement with the local community has always failed.[13]

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Chapter 10 Identifying and shortlisting waste management options

From a long list of options that CoRWM identified for the possible long-term management of waste, CoRWM used ten criteria to eliminate those that held out least promise for the UK. It developed a shortlist of four main options and subdivided them into 14 variants.

1. **CoRWM's terms of reference** made it clear that the Committee would need to start from a 'blank sheet of paper' in considering which radioactive waste management option or options to recommend to Government. This chapter describes how CoRWM identified its long list of options and then systematically evaluated them. This evaluation led to the screening out of most options on this long list, thus eliminating them from further consideration in the options assessment process. The result of this stage of CoRWM's work was the identification of a shortlist of options, and the next chapter describes how these shortlisted options were assessed. The whole process of shortlisting is described in more detail in 'How CoRWM short-listed the options'.[1]

2. **Identifying a long list of options.** Between April and September 2004, the Committee formulated a long list of potential management options, drawing on an earlier report to Government[2] and on advice from Nirex.[3] In formulating this list, CoRWM ensured that all options that had been given serious consideration by the international scientific community were included. Some options had been rejected elsewhere, in some cases because they breached international agreements, but the commitment to considering all options from a fresh stance led CoRWM to evaluate them all. The Committee considered whether or not it could rapidly eliminate impracticable options and whether this could be done simply, on a 'common sense' basis, or whether it needed information and a systematic process on which to base its decision. In order to provide a clear and unambiguous audit trail, the Committee decided that the process of elimination should be done systematically.

3. The draft long list of options was drawn up in September 2004. The PSE 1 consultation document (November 2004)[4] asked whether CoRWM had identified and adequately described all relevant options. The draft long list of options, as described in the consultation document, is shown in Box 10.1.

Box 10.1 CoRWM's long list of options

The options on CoRWM's long list were:

1. interim or indefinite storage on or below the surface
2. near surface disposal, a few metres or tens of metres down
3. deep disposal, with the surrounding geology providing a further barrier
4. phased deep disposal, with storage and monitoring for a period
5. direct injection of liquid wastes into rock strata
6. disposal at sea
7. sub-seabed disposal
8. disposal in ice sheets
9. disposal in subduction zones
10. disposal in space, into high orbit, or propelled into the Sun
11. dilution and dispersal of radioactivity in the environment
12. partitioning of wastes and transmutation of radionuclides
13. burning of plutonium and uranium in reactors
14. incineration to reduce waste volumes
15. melting of metals in furnaces to reduce waste volumes

4. **Defining an options shortlisting method.** The Committee developed a set of 'screening criteria' to eliminate those options on the long list that offered the least promise for the UK. These screening criteria were statements against which to judge options on a pass/fail basis. Box 10.2 describes these criteria. CoRWM's PSE1 consultation document sought views on these and on the proposed methodology for shortlisting. Early application of screening criteria allowed the screening process to start. This included: (a) feedback on the draft long list and proposed shortlisting criteria and methods from the first round of Public and Stakeholder Engagement (PSE1); (b) results from the commissioning of a total of 31 brief studies designed to help the Committee better understand key aspects of some of the options; and later (c) feedback on a proposed shortlist from PSE2. After assessing both PSE feedback and the results of the commissioned work, CoRWM was able to arrive at its shortlist by eliminating options which it regarded as unfeasible as they did not pass the screening test.

Box 10.2 Screening criteria that CoRWM applied to its long list of options

An option would be shortlisted if:

i. There is no 'proof of concept'

ii. It causes a breach of the duty of care to the environment outside national boundaries

iii. It causes harm to areas of particular environmental sensitivity

iv. It places an unacceptable burden on future generations, in terms of cost, effort or environmental damage

v. It involves a risk to future generations greater than that to the present generation that has enjoyed the benefits

vi. It results in unacceptable risk to the security of nuclear materials

vii. It poses unacceptable risk to human health

viii. The cost is disproportionate to the benefits achieved

ix. It breaches internationally recognised treaties or laws and there is no foreseeable likelihood of change in the future

x. It would involve implementation overseas when implementation could, in principle, be achieved in the UK (added as a result of public engagement).

5. Members of the public and stakeholders consulted in PSE1 generally felt that CoRWM had included all relevant options in its long list, although some had not been described with enough clarity. The screening criteria were also broadly endorsed, though there were suggestions from some respondents that extra criteria should be added. In particular, comments from participants in PSE1 strongly encouraged the Committee to consider explicitly the issue of the need to shortlist options which could in principle be applied within the UK's borders. CoRWM considered all suggested additions, but decided that only one – criterion 10 above – was important enough to add to the original nine.[5]

6. CoRWM refined the description of options throughout the shortlisting process, partly in response to PSE1 feedback. This included adding variants of some options and clarifying others. The most important example refers to option 1, storage. The Committee decided to draw a clear distinction between interim and indefinite storage and introduced two variants on storage described as option 1a, long-term interim storage, and option 1b, storage forever.

7. The 31 commissioned studies helped CoRWM to evaluate whether options would pass or fail the screening criteria. Most were subject to two peer review reports. Where, on the basis of information provided by the relevant study, CoRWM favoured the elimination of an option and the reasons for doing so were confirmed by initial peer review, no further scrutiny was, in general, carried out. CoRWM was concerned about the degree of criticism of the studies in some of the reviews. Of this process, the CoRWM external evaluator said:

> 'There was little chance of reports commissioned in this way and written at this speed meeting the standards that peer reviewers of this sort – and indeed stakeholders more generally – would probably have been expecting and many reviews were critical, pointing out significant omissions. … Even though the reports were fairly basic and the quality was variable, they seem in the end to have been adequate for their purpose.'[6]

8. **Deciding the shortlist**. Between November 2004 and February 2005, the Committee drew up a proposed shortlist of options for public consultation in April 2005 as part of PSE2. The shortlisting was a lengthy and deliberative process, including facilitated discussions at three plenary Committee meetings (November 2004, and January and February 2005). It was supported by substantial input and advice from working group meetings, especially the Information working group.

9. Plenary meetings considered each option in turn against all screening criteria to decide, with increasing conviction at each plenary, whether an option should be eliminated, or carried forward on the shortlist, for detailed assessment. The Committee decided that no option would be screened out unless it was unsuitable for all of the waste streams.

10. In the course of discussing the status of the long-listed options, CoRWM decided that the last four options were not complete waste management options in themselves. Rather, they were nuclear or waste process treatments that in some cases were already available to nuclear operators. These four options were therefore ruled out of the shortlisting process. Partitioning and transmutation was ruled out for the additional reason that there was no proof of concept and that the cost would be disproportionate to benefits derived. Having divided storage into the two distinct categories of interim storage and storage forever ('forever' replacing 'indefinite' in the original list of 15), 12 options were finally considered for shortlisting.

11. In the process of screening, each member was asked for views on all criteria in relation to all options. In the event, the decision on all shortlisted options was unanimous, while for those options eliminated, the decision was unanimous on seven out of eight cases, with two members dissenting in the case of sub-seabed disposal.

12. The CoRWM decision at the February 2005 plenary meeting was that four options should be shortlisted and eight options eliminated. The four that were provisionally proposed for the shortlist were:
    - **long-term interim storage**
    - **deep geological disposal**
    - **phased deep geological disposal**
    - **near surface disposal of short-lived wastes**.

13. Table 10.1 shows the eight eliminated options and the criteria which at least one member, in each case, cited as a reason for elimination (see reference[1] for more detail, as well as Annex 4)

Table 10.1 Criteria applied to screen out various options

Option	Criteria applied to screen out
Storage forever	Unacceptable burden to future generations Unacceptable risk to security of nuclear materials Unacceptable risk to health

Option	Criteria applied to screen out
Direct injection	No 'proof of concept' Causes harm to areas of particular environmental sensitivity Risk to security Risk to health
Disposal at sea	Breach of duty of care to the environment outside national boundaries Breach of internationally recognised treaties or laws and no foreseeable likelihood of change in the future
Sub-seabed disposal	Breach of duty of care to environment Harm to environmentally sensitive areas Involves a risk to future generations greater than that posed to the present generation that has enjoyed the benefits Breach of internationally recognised treaties or laws and no foreseeable likelihood of change in the future
Disposal in ice sheets	No 'proof of concept' Breach of duty of care to environment Harm to environmentally sensitive areas Risk to future generations Breach of internationally recognised treaties or laws and no foreseeable likelihood of change in the future
Disposal in subduction zones	No 'proof of concept' Breach of duty of care to environment Breach of internationally recognised treaties or laws and no foreseeable likelihood of change in the future
Disposal in space	Breach of duty of care to environment Harm to environmentally sensitive areas Risk to security Risk to health Cost disproportionate to benefits received
Dilution and dispersal	No 'proof of concept' Breach of duty of care to environment Breach of internationally recognised treaties or laws and no foreseeable likelihood of change in the future

14. At the July 2005 plenary meeting, CoRWM reviewed these provisional decisions on the shortlist, which are described in detail in reference[1]. To assist the Committee's review, the Information working group had carried out some further work to resolve some uncertainties identified earlier. The working group also looked again at the commissioned studies in light of the peer reviews, concluding that while none of the provisional decisions made in February needed to be revised, the points made in the reviews of the options proposed for shortlisting should be referred forward for use in subsequent option assessment.

15. The July 2005 plenary meeting also benefited from the results of PSE2 responses which, together with the working group's advice, were fed into the discussion. CoRWM decided that there should be no substantial changes to the provisional shortlist agreed in February. Few PSE respondents had argued for the reinstatement of options eliminated from the long list and none of the arguments made was considered substantial enough to require the reintroduction of eliminated options. Significant numbers of respondents had expressed

reservations about each of the shortlisted options, but CoRWM decided that these arguments could be more fully addressed at the detailed assessment stage. Some respondents had raised the issue of deep boreholes and the Committee agreed that these would be considered as a variant of geological disposal. Other respondents were concerned about the apparent finality of options' 'elimination' and CoRWM agreed that it would consider, later in its process, recommending that Government keep a 'watching brief' on some eliminated options (especially sub-seabed disposal and partitioning and transmutation).

16. CoRWM therefore confirmed that the first three options on the original shortlist – long-term interim disposal, deep geological disposal and phased deep geological disposal – were to be shortlisted. Document 1340[1] describes these deliberations in detail. However, some PSE respondents expressed uncertainty about the fourth option, the near surface disposal of short-lived ILW. In part, these uncertainties were shared by CoRWM itself, particularly the question of whether there was sufficient waste of this kind in the waste inventory to justify the possibility of including the option in the final shortlist.[7] CoRWM requested the Information working group to provide advice and deferred final consideration of the issue. At the October plenary meeting, CoRWM decided to shortlist 'near surface disposal of reactor decommissioning waste', an option description which replaced the earlier 'near surface disposal of short-lived wastes'.[8] This option can also be described as 'non-geological disposal' as it uses only engineered barriers, rather than the combination of engineering and geology, to provide for the containment of waste – some of which is long-lived – arising from decommissioned nuclear reactors. If regulatory agreement and public acceptance could be secured, this route might be preferable to the disposal of high volumes of waste in central facilities. A detailed account of why CoRWM decided to assess the non-geological disposal of reactor decommissioning waste is set out in CoRWM document 1381.[9] This document does not include the possibility, which CoRWM understands is undergoing preliminary assessment by the NDA, of decontamination and reuse of suitable reactor decommissioning waste, including graphite, steel and concrete.

17. **The final version of the shortlist**. Before moving to comparative assessment, CoRWM decided that it needed a more precise definition of the options. In light of important feedback from its PSE process, a decision was taken to define variants of the shortlisted options. For example, in the case of long-term storage, many people said that the transport of radioactive waste should be minimised, so storage at or very close to the sites where the waste is produced or currently located, as well as centralised storage, was included as a variant. Most people considered that the waste should be protected from attack by terrorists and so variants where the protection that is provided in the existing stores is enhanced to withstand potential attacks, as well as additional protection applied to new stores, was added to the shortlist. Some respondents thought that the waste should not be stored underground, so two concepts of providing enhanced protection were considered. In the first, it would be provided by an engineered structure on the surface; in the second, the waste would be stored underground and the protection would be provided by the overlying rock.

18. In the case of geological disposal, CoRWM also considered boreholes for the most active waste streams, since they have the potential to achieve better isolation of the waste from humans and the environment than conventional geological disposal. Boreholes have been considered as an alternative to geological disposal in countries overseas such as Sweden. CoRWM did not consider local geological repositories for the higher activity wastes, since building a geological repository at every site would be prohibitively expensive and the geology might not be suitable.

19. However, in view of the importance that many people attach to minimising the transport of radioactive material, CoRWM did consider local near surface

repositories for reactor decommissioning waste (see section 6 of Annex 4), which, unlike the waste from reprocessing, contains only small quantities of long-lived radioactivity. Near surface vaults like those at the LLWR near Drigg in Cumbria constitute one concept, but they could be susceptible to coastal erosion at many existing sites. The Committee therefore also considered the design that is being used for short-lived waste in Sweden and Finland, which is below ground but at a much shallower depth than for a geological repository for long-lived waste. CoRWM also considered the concept of using the biological shield of the reactor as the engineered barrier developed in the UK in the 1990s and known as 'mounding over' reactors.

20. These deliberations led, in November 2005,[10] to the headline description of shortlisted options and variants shown in Box 10.3.

Box 10.3 Headline descriptions of CoRWM's shortlisted option and their variants

Long term interim storage

1. Interim stores, above ground, at or near current locations of waste and protected to current standards
2. Interim stores, above ground, centralised and protected to current standards
3. Interim stores, above ground, at or near current locations of waste and protected
4. Interim stores, above ground, centralised and protected
5. Interim stores, underground, at or near current location of wastes and protected by ground cover
6. Interim stores, underground, centralised and protected by ground cover

Geological disposal

7. Geological disposal
8. Deep borehole disposal

Phased geological disposal

9. Phased geological disposal

Near-surface disposal of short-lived wastes

10. Near surface engineered vaults, at or near current locations of waste, protected
11. Near-surface engineered vault, centralised, protected
12. Mounded over reactors
13. Shallow vault disposal, centralised
14. Shallow vault disposal, at or near current locations of waste

CoRWM dropped the description 'deep' from options 7 and 9 as the term had no clear meaning, and all future references in this report are to 'geological' disposal. The term 'deep' is reserved for boreholes.

21. **Conclusion**. CoRWM drew up a long list of waste management options in September 2004 and then deliberated at length on both the process and substance of shortlisting. It used two rounds of Public and Stakeholder Engagement and some brief commissioned studies to inform the deliberations. The shortlist for detailed assessment, broadly confirmed in July 2005, contained three options that could in principle apply to the whole of the CoRWM inventory – interim storage, geological disposal and phased geological disposal – as well as near surface disposal for decommissioning wastes. The Committee subdivided these options into a total of 14 variants that went forward for more detailed assessment, as explained in the next chapter.

References

1 Committee on Radioactive Waste Management, "How CoRWM short-listed the options", document 1001.4, May 2005 and Committee on Radioactive Waste Management, "Outcome of short-listing", document 1340, September 2005.

2 Wilkinson Environmental Consulting Limited, "Information Needs Research Project - Identification of Information Needed to Decide with Confidence on the Long Term Management Options for Long Lived Radioactive Waste", Defra Report No: DEFRA/RAS/02.014

3 UK Nirex Limited, "Description of Long-term Management Options for Radioactive Waste Investigated Internationally" Nirex Report N/050, May 2002.

4 Committee on Radioactive Waste Management, “PSE1 Consultation Document”, document 831, November 2004.

5 Committee on Radioactive Waste Management, "Minutes of the February 2005 plenary meeting", document 1002, April 2005.

6 Faukland Associates, “CoRWM Phase 2 Evaluation”, October 2005.

7 Committee on Radioactive Waste Management, "Minutes of the July 2005 plenary meeting" document 1311, July 2005 and Committee on Radioactive Waste Management, "Outcome of short-listing", document 1340, section 3.12, September 2005.

8 Committee on Radioactive Waste Management, "Minutes of the October 2005 plenary meeting", document 1362, October 2005.

9 Committee on Radioactive Waste Management, "Why CoRWM short-listed the non-geological disposal of reactor decommissioning wastes", document 1381, October 2005.

10 Enviros, "Summary descriptions of CoRWM's short-listed options", document 1420, November 2005.

Chapter 11 Assessing the shortlisted options

CoRWM used Multi-Criteria Decision Analysis to conduct a thorough performance assessment of its shortlisted options for the entire waste inventory, against a number of criteria. It complemented this with an holistic assessment of the options, and compared the outcomes of the two assessments.

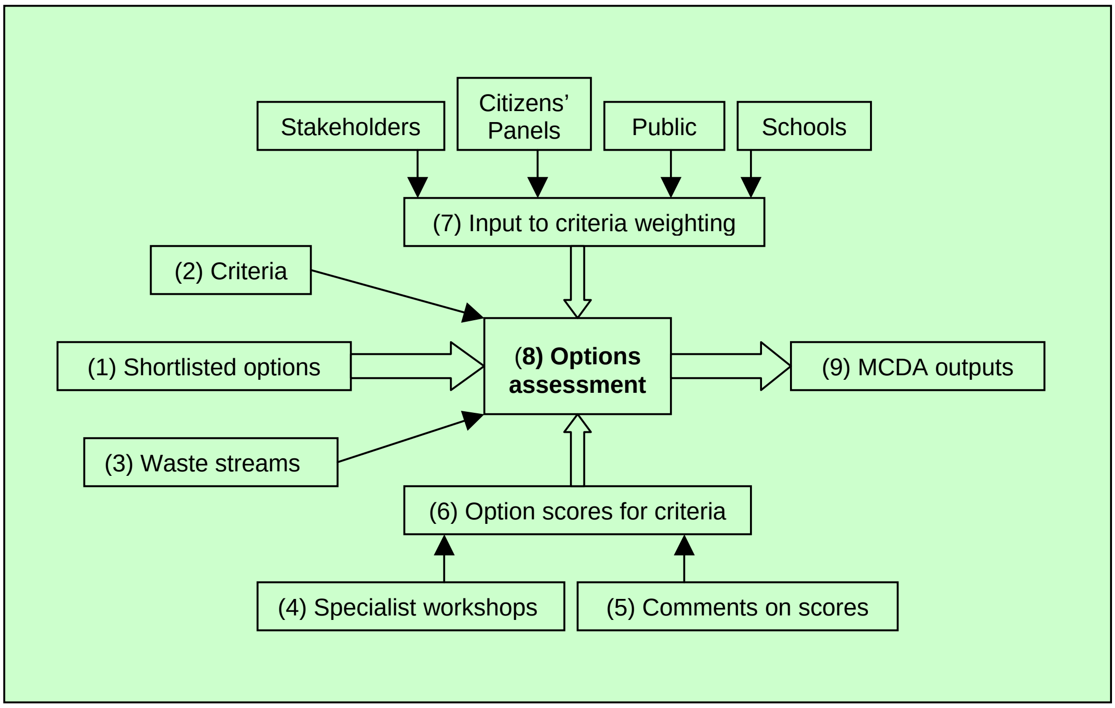
Method

1. CoRWM developed a bespoke options assessment process in close consultation with decision analysts, experts in process design and specialists in stakeholder engagement. The outline process was put out for public and stakeholder comment in PSE2, and resulting feedback was used by CoRWM to develop the detail of the process. The underlying philosophy was to draw on both scientific and technical inputs and views expressed by the public and stakeholders, using the principles of deliberation whenever appropriate. The Committee agreed early on that its role was not merely to collate and pass on the views of others, but that it would make its own judgements, fully informed by those views. The principles that were adopted for options assessment were:

    - a rational and systematic approach, using the best available specialist inputs, with scope for iteration at key points, within a discursive, ethically informed, and integrative framework
    - transparency and traceability, so that the way in which the decisions were arrived at was clear
    - robustness, including the means of taking public and stakeholder engagement and specialist outputs into account.

2. Two complementary assessment methods were adopted. An MCDA technique[1] enabled the shortlist of options to be assessed against those criteria judged to be important by citizens of the UK, as identified, for example, by the Citizens' Panels (see Chapter 7). This allowed rigour to be applied in an open and transparent way that could provide an audit trail of the judgements and decisions made. This bottom-up and relatively mechanistic approach was complemented by a more holistic approach in which the options were assessed as a whole. The rationale for the linking of the two methods, and the way in which they were conducted, was consistent with Renn's Cooperative Discourse Methodology.[2] Additional detail on options assessment is given in Annex 4.

Figure 11.1 Overview of the MCDA assessment process



3. MCDA allows three important and distinct analytical processes: (a) specialists or experts to deliberate and reach quantified judgements about the performance of options against the set of agreed criteria; (b) societal judgements to be applied to determine the relative importance to attach to each of the criteria; and (c) a combination of these two earlier processes to produce a picture, part scientific and part value-driven, of the overall ranking of each option. Such MCDA processes cannot make the choice between options, but they can provide a wealth of useful and structured information and judgement, deepen understanding and raise important questions for further deliberation.

4. Figure 11.1 shows CoRWM's MCDA assessment process in more detail. It involved assessing the shortlisted options (1) against a set of criteria (2) identified as being important through engagement with stakeholders and the public. This assessment was done initially for HLW and then for each of the other waste streams (3) by considering what changes in the assessment might arise from the characteristics of that waste. The scoring (quantified performance assessment) of the options against the criteria was carried out by specialists with appropriate expertise and knowledge (4) and there was an opportunity to comment on those scores (5). The scores were fed into the Hiview model, a software programme that was being used for the MCDA assessment (6). The relative importance of the criteria used to assess the options is a value-laden judgement. While CoRWM made the final judgement on the weight that should be given to each criterion, a wide selection of stakeholders and members of the public provided input that was taken into account (7). CoRWM undertook the options assessment in public (8), producing baseline models for each waste stream, and exploring the implications of varying option scores and criteria weights in sensitivity testing. The outputs of the MCDA (9) were analysed and discussed, providing a good understanding of how each of the options was expected to perform, and where the strengths and weaknesses of each lay.

The waste streams

5. The assessment of the options was carried out for each waste stream. There were originally seven waste streams or materials that were scored by the specialists, each of which, it was believed, had sufficient unique characteristics to merit separate assessment. This could either be because they might score differently against some of the criteria, or because those criteria might be weighted differently for some types of waste. As an example, preventing the theft of plutonium was considered to be particularly important compared to the theft of other materials. The rationale for selecting these waste streams can be found in Section 3 of Annex 4. The original seven waste streams or materials were:

   - high level waste
   - spent nuclear fuel
   - plutonium
   - highly enriched uranium
   - intermediate level waste and low level waste not suitable for the low level waste repository near Drigg (intermediate level waste and non-Drigg low level waste)
   - depleted, natural and low enriched uranium
   - reactor decommissioning waste.

6. During public and stakeholder engagement it was pointed out that the small amount of highly enriched uranium in the inventory would be mixed with the other uranium streams making just one category of uranium for potential disposal. [3]

The assessment criteria

7. The options were assessed against criteria that the public and stakeholders considered to be important. These were developed with input from many sources and modified as a result of the public and stakeholder process as described in Chapter 7 As a result, a 'value tree' (see Section 2 of Annex 4) was compiled that captured the majority of the issues that people considered to be important and these were grouped into the 11 headline criteria and their associated 27 sub-criteria as shown in table 11.1.

Table 11.1 Value tree of assessment criteria

Headline Criterion	Sub-Criterion	Extent to which the option is expected to …
1 Public Safety, Individual – short term (up to 300 years)	1 Radiation	protect individual members of the public from exposure to radiation during the first 300 years
	2 Non-radiation	minimise the numbers of deaths and serious accidents by the public (attributable to its construction and operation)
2 Public Safety, Individual – long term (longer than 300 years)	3 Radiation	protect individual members of the public from exposure to radiation beyond 300 years
3 Worker Safety	4 Radiation	protect workers involved in its operation from exposure to radiation

Headline Criterion	Sub-Criterion	Extent to which the option is expected to …
	5 Non-radiation	minimise deaths, industrial and occupational diseases and serious injuries as a consequence of its construction and operation
4 Security	6 Misappropriation	prevent unauthorised removal of hazardous material
	7 Vulnerability to terrorist and other attack—pre-emplacement of waste	withstand reasonably foreseeable malicious and purposeful attacks, taking into account transport and emplacement timescales
	8 Vulnerability to terrorist and other attack—post emplacement of waste	withstand reasonably foreseeable malicious and purposeful attacks
5 Environment	9a Radiological pollution <300 years	minimise radioactive releases that could have harmful effects on ecosystems, flora and fauna, and/or the built environment over a timescale less than 300 years.
	9b Radiological pollution >300 years	minimise radioactive releases that could have harmful effects on ecosystems, flora and fauna, and/or the built environment over a timescale beyond 300 years.
	10 Chemical pollution	minimise chemical releases that could have harmful effects on ecosystems, flora and fauna, and/or the built environment over the timescale of interest.
	11 Physical disturbance	minimise the effects of noise, vibration, light pollution and earthworkings on ecosystems, flora and fauna during construction, operation and post-operation
	12 Use of natural resources	minimise the use of natural resources, including energy, construction materials, packaging materials and water;. also consider change of land use and indirect impacts
6 Socio-Economic	13 Employment	employ people over the option's lifetime
	14 Spin-off	create, in addition to direct employment, significant spin-off opportunities: e.g. jobs, skills, knowledge in both technology and business, and investment
7 Amenity	15 Visual	create a visual impact
	16 Noise	create a noise impact at the boundary of the site for a single instance of the option
	17 Transport	create a transportational impact outside the site boundary for a single instance of the option
	18 Land take	create an impact at a single site on a single individual through surface land take
8 Burden on Future Generations	19 Cost	reduce the financial liability (whole life costs) imposed on future generations
	20 Effort	reduce managerial effort for all aspects of implementation imposed on future generations, including the pre-operational phase
	21 Worker Dose	reduce exposure of the workforce imposed on future generations

Headline Criterion	Sub-Criterion	Extent to which the option is expected to …
	22 Environmental impact	reduce the environmental burden imposed on future generations, taking into account pollution, physical disturbance, use of natural resources, visual impact, noise, transport and surface land take
9 Implementability	23 Technical	employ currently established, tested and proven technical methods for the design, construction and operation of the option, including decommissioning, if relevant
	24 Regulatory requirements	be fully consistent with international, EU and national law and regulatory requirements
10 Flexibility	25 Flexibility	allow for future choice and respond to unforeseen or changed circumstances over the 300 years
11 Costs	26 Costs	minimise total costs of the final management of wastes, taking into consideration: • development • implementation • operation • closure • monitoring

Time periods

8. The nature of the shortlisted options is such that they cover different timescales. A decision was needed on how to compare options that were designed to be permanent with those designed for a finite period after which further management action would be needed. In order to make a fair comparison between the storage options and the disposal options, this period of storage had to be quantified. Criteria that measured impact over longer periods would then not be used in the multi-criteria analysis, as this analysis could only compare options over the period of time that they would all be operational. CoRWM decided on a 'reference case' of storage for a maximum of 300 years. This took into account various factors, including the practicability of maintaining institutional control over stores and refurbishing and rebuilding them as necessary. UK regulators are unlikely to accept a safety claim for institutional control for a period of greater than 300 years. This is also the period of time over which short-lived ILW from reactor decommissioning decays to non-hazardous levels. For the purposes of the comparative assessment in the MCDA, both disposal and storage options were therefore evaluated over only a relatively short (300 year) period. While this clearly limited the scope of the MCDA, it did not invalidate its use as a tool for comparing the options over this period. Indeed, it focussed the Committee's attention on the need to fully assess the impact on public safety and the environment of the disposal options beyond 300 years, and whether this might be a burden on future generations because of the possibility that generations in the far future might experience serious health consequences as a result of repository failure.

Judging option performance: scoring the options

9. One of CoRWM's guiding principles is 'to aim for a safe and sustainable environment … by applying the best available sound science and other specialist input'. The Committee therefore decided that the task of scoring the options should be undertaken by specialists.

10. CoRWM consulted widely to identify specialists from a range of disciplines and viewpoints with demonstrable in-depth knowledge of the various aspects of the value tree. Those who agreed to participate were organised by CoRWM into criteria-specific workshops. CoRWM appointed, on the basis of competitive tender, a decision analysis consultancy (Catalyze) to help design and run the workshops. The Committee took the view that, even at the sub-criterion level, responding to the mix of concerns required a multidisciplinary approach. Thus, the composition of the specialist groups assembled to carry out the specialist strand of the MCDA drew on many different scientific and technical backgrounds. Membership of the workshops was designed to allow the representation of a spectrum of opinion, including both the nuclear industry and the environmental NGOs, as well as various 'non-aligned' groups such as the regulators. While a good spread of expertise was achieved in most of the workshops, NGO representation was less than had been hoped for, particularly in the safety workshop. This may have led to greater consensus on the scores than might otherwise have been the case. This was mitigated by providing an opportunity for people to comment on the scores, and for those views to be taken into account during sensitivity testing (see paragraphs 23 onwards).

11. The first task for the specialists was to create scoring schemes for each of the sub-criteria. The specialists were then asked to score each of the options against each of the sub-criteria, ensuring that their rationales were fully recorded.[4] These scores were put out for comment and the resulting feedback was used to compile a comprehensive report on scores that was used during the conduct of the actual multi-criteria analysis.[5] Further details on the specialist workshops can be found in section 4 of Annex 4.

Weighting the criteria

12. The Committee wished to ensure that the importance, or weight, that was given to each criterion reflected the values and ethical positions of the public and stakeholders by taking their views into account. A large element of PSE3 therefore involved different organisations or individuals giving their views in ways that were appropriate for them. This included:

- The four Citizens' Panels that gave their views on the relative importance of the 11 headline criteria.[6]

- The National Stakeholder Forum and Nuclear Site Round Tables that carried out a more detailed exercise providing input for all 27 sub-criteria.[7]

- A Discussion Guide that enabled several thousand members of the public, including schools, to meet in groups and to use the guide to steer themselves through a discussion, the results of which they reported back to CoRWM. This provided views on the relative importance of headline criteria.[8]

- A project with schools in Bedfordshire that allowed 15 schools to provide input gained from consulting with their peers on the relative importance of headline criteria.[9]

13. While criteria have an intrinsic value or importance, the weight they are given in a relative assessment of options needs to take into account how much of a discriminator they are between those options. As an example, cost may be a very important criterion when buying a new car, but if all the cars under consideration cost much the same, then other criteria become more important as discriminators. CoRWM members therefore engaged in a 'swing weighting' process, guided by Professor Larry Phillips (Catalyze Limited). This involved making judgements on

the relative importance of sub-criteria, once the difference between the top and bottom of the scoring scales for those criteria was taken into account. Thus the question to be answered in each case was: How big is the difference between the top and bottom of the scoring scale, and how much does it matter? Once the sub-criteria had been given relative weights, another process was used to aggregate the weights up to headline criteria level, undertaking frequent checks to ensure logic/rationality. Throughout the exercise, CoRWM members drew on the input from PSE3.[10] The full swing weighting process was carried out in public.[11]

14. The relative weights CoRWM gave to the headline criteria are shown in Table 11.2.

Table 11.2 Relative weights given to headline criteria

Headline Criterion	Weight (%)
Public Safety, individual, short term (up to 300 years)	23.3
Security	23.3
Burden on Future Generations	16.0
Flexibility	16.0
Worker Safety	7.7
Environment	7.1
Implementability	4.0
Amenity	1.7
Socio-economic	0.9
Total	**100**

15. It must be remembered that the weights in the table are relative weights, and that judgements were being made on these criteria as discriminators between the generic options. It should not be taken to imply, for example, that amenity and socio-economic issues are not important. Such issues will increase in importance and be addressed through the siting process. Even during the scoring workshops, the specialists commented that it was difficult to score those criteria that depended to a large extent on the specifics of the site.

16. Two headline criteria are missing from the above weighted list of criteria:

- **Public Safety, individual, long term (greater than 300 years).** As explained in paragraph 8, disposal and storage options were compared over the short term (300 years) in the MCDA, and assessments on the long term safety of the disposal options were conducted elsewhere.[12]

- **Cost.** The specialists considering the cost of the options provided their best estimate of the cost of each option. There was a great deal of uncertainty associated with their figures, and a resulting large spread between the low and high estimates. There was also less difference between the options than expected.[2] CoRWM therefore decided to keep the cost criterion separate from the other criteria in the MCDA, and to assess the impact of cost through a form of sensitivity testing.

It is noteworthy that CoRWM's weights were largely consistent with many of the views on weights received during PSE3. Stakeholders provided input on the weighting of sub-criteria.[11] Table 11.3 provides an overview of the input of citizens and young people.

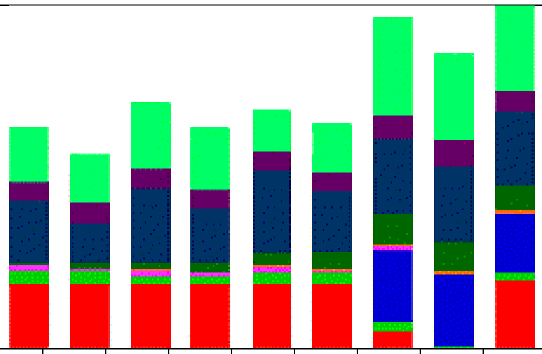
Table 11.3 Overview of the input provided by citizens and young people

Rank	CoRWM	Citizens' Panels	Schools' Project	Discussion Guide
1	Safety short term	Security	(Safety long term)	Environment
2	Security	Safety short term	Safety short term	Security
3	Burden	(Safety long term)	Environment	(Safety long term)
4	Flexibility	Burden	Security	Safety short term
5	Worker safety	Flexibility	Worker safety	Flexibility
6	Environment	Environment	Burden	Burden
7	Implementability	Worker Safety	Socio-economic	Worker safety
8	Amenity	Implementability	Amenity	Implementability
9	Socio-economic	Socio-economic	Implementability	Socio-economic
10	Safety long term and Cost not weighted – see paragraph 15	Amenity	Flexibility	(Cost)
11		(Cost)	(Cost)	Amenity

High level waste outputs

17. The specialist scores for HLW and the CoRWM swing weights were entered into the Hiview programme to create a model for HLW. This was called the baseline case on which the majority of the sensitivity testing was carried out. Table 11.4 shows how the various options performed for HLW.

Table 11.4 HLW baseline case with specialist scores and CoRWM swing weights

Criteria	Option	Cumulative Weight
Safety <300 yrs		23.3
Worker Safety		7.7
Security		23.3
Environment		7.1
Socio-Economic		0.9
Amenity		1.7
Burden on Fut Gen		16.0
Implementability		4.0
Flexibility		16.0
	1 2 3 4 5 6 (Storage) 7 8 9 (Disposal)	
Total		**100.0**

18. The coloured portions of the bar chart show the relative contributions of the headline criteria to the totals. For example, the borehole option lacks flexibility, so no red portion shows. The large blue sections, showing a high score for the burden criterion, and therefore a lower burden on future generations, are a major reason for the higher total scores for the geological disposal options. Even if the weight on the burden headline criterion were halved, making the blue portions half as long, the geological disposal options would still achieve higher overall scores than the storage options. The short-term safety criterion is also an important discriminator because of the vulnerability of storage options if there was a loss of institutional control.

19. Phased geological disposal achieves the highest weighted score, though geological disposal is similar. The main discriminator between the two is the amount of flexibility provided by each. The judgement of some specialists was that phased geological disposal provides even higher levels of flexibility than storage, because storage would need significant further action before a genuinely long-term option could be implemented, whereas a repository could be closed relatively simply. At the same time, phasing is deemed to reduce the burden on future generations to almost the same degree as geological disposal, even though the latter involves early closure of the respository. This starts to reveal the complexity of the arguments surrounding the burden and flexibility criteria, discussion of which was developed during the holistic assessment.

20. All the geological disposal options score better than the storage options, mainly due to the reduction in burden and increase in safety. The operation of the burden on future generations criterion is based on the assumption that geological disposal reduces the burden whereas storage does not. This assumption is challenged by at least one member of CoRWM who believes, first, that geological disposal may create a burden if anything goes wrong and, second, that institutional arrangements and storage design could reduce the burden associated with storage.

21. Current site storage options all score better than their associated centralised options. The largest contributor to this difference is the security criterion, reflecting a judgement that transporting waste to a central location creates a greater risk of terrorist attack. The best performing storage option is above ground enhanced

protection, at current sites, reflecting the specialists' judgement that this is the safest of the storage options.

22. Overall:

- The key discriminators between geological disposal and storage options were burdens on future generations and public safety (up to 300 years). This was because the specialists had judged that, within the limitations of the assessment process, disposal options perform significantly better than storage options against these criteria and they were highly weighted by CoRWM.

- Phased geological disposal ranked slightly higher than geological disposal because, based on the specialist scores, the former performs better against the flexibility criterion, which was weighted heavily.

Sensitivity testing

23. In both the scoring of options and the weighting of criteria, judgements were being made. CoRWM had asked specialists to score the options using their knowledge and expertise. The resulting scores depended on the best judgements of those attending the specialist workshops. They were used to construct the baseline case, as described earlier, from which the impact of variations in scores could be explored. Similarly CoRWM members used their best judgements to provide criteria weights for the baseline model from which the implication of varying those weights could be explored.

24. The large amount of material from PSE weighting exercises and from the opportunity to comment on specialist scores was collated into two papers. [13] [14] The lowest and highest scores and/or weights favoured by participants and respondents were identified, and the relative strengths of the various views could be assessed. It was not possible to test every individual viewpoint in the model, and there were differences of view within sectors (for example not all NGOs made the same judgements), however sector trends could be identified. These trends were represented by picking scores and weights that were judged to reflect the upper and lower limits of the sector views. This was called the 'limiting case' as it reflected the most severe test for each of the sectors' views. Table 11.4 gives the scores for each of the options for HLW, with the original base case shown for comparison.

25. Although some scenarios included large changes to individual criteria weights, these did not change the overall ranking of geological disposal and storage options. In all instances, the geological disposal options were ranked higher than the long-term storage options, although in some cases the 'gap' between them was significantly reduced.

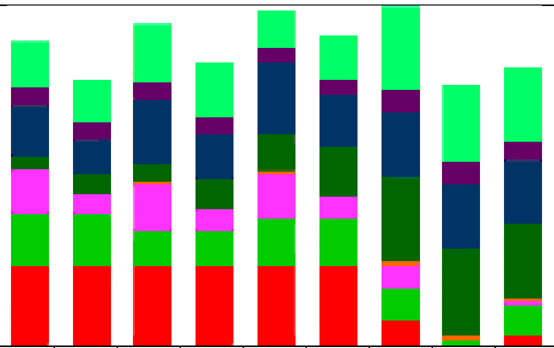
26. For the sensitivity testing of the cost criterion, the highest cost estimates for disposal and the lowest cost estimates for storage were fed into the model. The storage options, despite their lower costs, continued to perform less well than disposal.

NGO limiting case

27. The most severe test was provided by a combination described as the 'NGO limiting (bounding) case'. This involved much more weight being placed on environment, amenity, flexibility and implementability criteria. These weights, combined with reduced scores for geological disposal options against burden on future generations to the same levels as for storage options, reflected concerns

that disposal options could impose substantial burdens on future generations if poor repository performance resulted in substantial negative environmental impacts and clean-up effort in addition to a negative impact on human health. The score for flexibility for phased geological disposal was reduced to the same as that for geological disposal to reflect a view that social and political hurdles could prevent retrieval of wastes during the open phase of a repository. Even in this case, geological disposal still ranked highest, though followed extremely closely by underground local stores. The two criteria that caused this storage option to perform better than the previous top scoring storage option (above ground local stores with enhanced protection) were implementability and the environment. The increased weight on these criteria enhanced the difference in scores between the two, with the underground option judged to be more easily implementable and more sympathetic to environmental concerns. Phased geological disposal ranked below some of the storage options mainly due to the reduction in scores for this option against flexibility and burden criteria. This was the only sensitivity test that placed any storage options broadly on a par with geological disposal options.

Table 11.5 HLW NGO Limiting Case

Criteria	Option	Cumulative Weight
Safety <300 yrs		15.6
Worker Safety		5.2
Security		15.6
Environment		15.6
Socio-Economic		0.6
Amenity		10.7
Burden on Fut Gen		10.7
Implementability		10.7
Flexibility		15.6
	1 2 3 4 5 6 7 8 9 Storage (1–6) Disposal (7–9)	
Total		**100.0**

Results for other waste streams

28. The criteria weights derived for HLW were entered into the models for the other waste streams, and sensitivity tests were conducted to reflect views on whether different weights should apply to some criteria for different waste streams. The ranking of the options for HLW, spent nuclear fuel, and plutonium were virtually identical. For uranium, the gap between the storage and disposal options was much narrower, and small changes in weights for the burden and flexibility criteria would lead to an overall preference for underground central storage. The reason for this result was that the level of hazard is potentially lower than for other materials and that it is possible to recycle uranium in future fuel. For ILW, geological disposal ranked highest, followed by phased geological disposal. This was mainly due to lower specialist scores for short-term safety of ILW when a disposal facility is left open. For reactor decommissioning wastes, shallow vault disposal ranked very similarly to geological disposal, mainly reflecting confidence in the safety of non-geological disposal options for this type of short-lived waste.

29. The outputs from the MCDA highlighted those criteria that were acting as discriminators between the options, and drew attention to those that were particularly sensitive to variation. The exercise also identified several issues that required further clarification and debate within the Committee.

Multi-Criteria Decision Analysis – conclusions

30. It is important to recognise that MCDA models are not intended to provide the 'right' answers. They are a tool to aid exploration and not a means to identify a result. When dealing with the future, there is considerable uncertainty and conflicting objectives. Models are only approximations of the reality they attempt to represent; real-world elements are omitted, complex relationships are simplified, and distinctions are blurred. The model was used as an aid to thinking, first serving as a means to add depth to the options-and-criteria framework that CoRWM had already adopted, adding the principles of scoring and weighting. MCDA provided a means for the many pieces of the complex problem to be dealt with separately, with data and judgements exercised about the pieces. Next, it reassembled the pieces according to multi-criteria decision theory. Finally, the role of the model shifted as model outputs were revealed, and sensitivity testing enabled MCDA to serve as an aide to decision making.

31. The MCDA did have some limitations specific to CoRWM's issue. It was unable to accommodate the differing timescales over which the options operate, leaving a critical aspect of the radioactive waste problem to be assessed separately (see paragraph 8). Another important issue, that of cost, was also dealt with in a different way to the other criteria. The nature of the problem with seven waste streams, 14 options, and 27 sub-criteria, plus the involvement of so many different people, proved challenging but not insurmountable. In the words of CoRWM's independent evaluator, 'Despite the inherent limitations and some implementation issues raised by ourselves and others, our conclusion is that the MCDA was valid, had value, and can make a significant contribution to the decision-making'.[15]

The MCDA analysis led to three conclusions:

- Overall, geological disposal options ranked higher than storage options.
- The difference in ranking between geological disposal and storage is substantial for most waste streams and for most of the limiting case sector scenarios.
- Generally, the borehole option is the lowest ranked geological disposal option.

32. The four headline criteria that generally received the highest weighting were: safety during the first 300 years, security, burden on future generations, and flexibility. The significance of different views on the way these criteria interact is discussed in Chapter 13 where the limitations of the MCDA and thus the value of the outcomes from it are examined.

33. The higher ranking of phased geological disposal compared to geological disposal for all waste streams, except ILW depends mainly on the specialist view that the phased concept gives much more flexibility. This is due largely to the fact that phased disposal is assumed to enable retrieval of waste although most members of CoRWM, and many stakeholders, argue that, once emplaced, waste is unlikely ever to be retrieved. If phased geological disposal is given a low score for flexibility then geological disposal would, overall, be ranked higher than phased geological disposal. Likewise, the assumption that disposal removes the burden on future generations is not universally accepted.

The holistic assessment

34. MCDA is a useful tool in decision making because it can accommodate both quantitative data derived from science, and qualitative data based on values and ethical considerations. CoRWM also wished, however, to compare the shortlisted options in the round (rather than by criteria), in a less constrained way. The use of a second, more holistic assessment, run in parallel with an MCDA, is entirely consistent with Renn's Cooperative Discourse Model. The proposal to include another method of assessment alongside the MCDA also received support from the public and stakeholders.

35. The steps in the holistic assessment were:

- A number of discussions over a period of several months on specific aspects of the problem, at workshops, in plenary discussions, and using panels of specialists. Each discussion was supported by briefing papers, and conclusions reached were recorded.

- Sessions during PSE3 that allowed participants to express their option preferences and reasons for their views. This was done at the National Stakeholder Forum, at the eight Nuclear Site Round Tables, at the four Citizens' Panels, during the Conference at the end of the Bedfordshire Schools' Project, and by the groups using the Discussion Guide. The outputs were used to inform CORWM members when undertaking their own assessment.[16]

- Additional discussions to clarify views on critical issues immediately prior to the actual assessment by CoRWM.

- A visual representation of CoRWM members' views of their provisional option preferences.

- Discussion of those views and the underlying rationales.

36. The discussions and/or panels on specific issues included:

- **Long-term safety of geological disposal.**[17] (see Chapters 8 and 13).

- **Ethical considerations**.[18] A crucial issue is how the well-being of future generations should be protected (i.e. intergenerational equity). As discussed in Chapter 6, the key question is whether one should 'deal with the waste now or later'. In the case of radioactive materials that are considered to be waste (i.e., they have no value), most members considered that there is a case for starting to implement some form of geological disposal as soon as practicable because this would reduce the burdens handed on to future generations. These burdens included the need for refurbishing stores and repackaging the waste as both deteriorate with time. However, placing the waste 'out of sight' should not result in it being 'out of mind'. Ensuring that this does not happen in the foreseeable future will involve monitoring, marking of the site and ensuring documentation is handed down from generation to generation. While monitoring would be useful to maintain knowledge of repository performance, it would probably have severe limits, as it is difficult to imagine the conditions under which waste from a repository would be retrieved once it was sealed. An alternative view was opposed to the need to begin disposal as soon as practicable because of the concern over imposing a burden of uncertain risks on future generations and a desire to maintain the active management of wastes for as long as possible. There was also a concern that potential options would be ruled out prematurely by moving too quickly to geological disposal.

- **Environmental principles.**[19] Most of the well-established environmental principles were discussed and were found not to discriminate between options. For example, the precautionary principle could be argued to support either long-term storage or geological disposal, depending on an individual's views on the nature and scale of the uncertainties and risks associated with each option. Similarly, the argument that the principle of 'concentrate and contain' favours storage rather than disposal (on the grounds that disposal inevitably results in eventual dispersal) can be countered by the argument that the vulnerability of storage to external risks meant that containment could not be guaranteed, and that the primary intention of geological disposal was to provide geological isolation on timescales sufficient to exploit radioactive decay. However these external risks in relation to storage could be mitigated by careful design and siting of stores, bearing in mind potential risks from climate change.

- **Institutional control**. The Committee commissioned papers on 'Institutional Control'[20] which were reviewed[21] and used as the basis for a plenary discussion on the subject in January 2006. The main points from this discussion were that it was difficult to argue that institutional control could definitely be maintained, even over periods measured in decades, and that both storage and phased geological disposal depended on institutional control being maintained.

- **Lifetime of stores**. A number of organisations were consulted for their views on the maximum lifetime of stores, and a panel was convened to discuss storage at the plenary in February 2006. Current stores are designed to last 50–100 years and require internal refurbishment of equipment approximately every 25 years. Research into longer life stores is ongoing but there was general doubt about stores having a lifetime beyond 300 years due to concerns including potential loss of institutional control.

- **Lifetime of waste packages**. The lifetime of waste packages was covered at the same panel discussion on storage in February 2006[22] There was a firm view from the regulators that package lifetimes are currently about 150 years, and that further research and development would be required if there was a need to extend this.

- **Retrievability**. The subject of retrievability was first discussed at a plenary on 16 September 2005 (and was revisited at the plenaries in December 2005 and February 2006). The reasons why many members of the public and stakeholders favoured retrievability were discussed, and whether these requirements could be provided by phased geological disposal or whether they really indicated that storage would be more appropriate. This dichotomy has already been reflected in the way flexibility was handled in the MCDA, and is discussed further below and in more extended form in Chapter 15.

37. As part of the holistic assessment process, members indicated their provisional option preferences for each waste stream. This helped to build up a picture of which options were more favoured than others. The picture that emerged showed that:

- For HLW, spent fuel, ILW and plutonium, a large majority of members indicated a preference, as a starting point, for forms of geological disposal, reflecting the majority view of confidence in long-term safety and views on intergenerational equity. Some members preferred the borehole option for spent fuel and plutonium because it would provide the maximum protection against the misappropriation of these sensitive materials. The remaining preferences were for forms of storage, reflecting a lack of confidence in the long-term safety, and intergenerational issues, and a reluctance to deny future generations the option of finding alternative management methods as well as the possibility of using the waste as a resource.

- For uranium, less than half the preferences were placed under forms of geological disposal and the picture reflected mixed views about the potential use of the uranium as a resource, and awareness that these forms of uranium are relatively low hazard materials.

- For reactor decommissioning wastes, just under half of the preferences were for shallow disposal at or near existing sites. There was an implicit assumption that any such site would be suitable in terms of its resistance to climate change and/or coastal erosion. The preferences reflected a view that – where appropriate – such facilities could be utilised for short lived ILW from reactor decommissioning, in part to avoid the transport of relatively bulky material to a central facility but would have to be subject to an approved safety case and public acceptability.

38. Through discussion of provisional views on options, the assumptions that members had made about the wastes and/or the options were uncovered, leading to more intensive deliberation about the underlying issues. Reasons for agreement, and particularly disagreement were investigated. [23] The main outputs included:

- The two storage variants based on protection to current standards did not receive any support for any waste category. It was therefore agreed that these variants should not be recommended as options for the long-term management of radioactive wastes. It was noted, however, that in the shorter term such stores already exist and could form an integral part of a strategy for implementing a long-term management policy.

- There was a wide range of views on phased geological disposal and the Committee returned to a discussion of this option on a number of occasions. Some members were highly sceptical about the value of leaving a repository open for an extended period prior to closure arguing that it imposes cost and effort burdens on future generations for little real gain thereby undermining the removal of burden principle upon which the case for disposal partly rests. They felt that it would not offer any real prospect for reducing the uncertainties associated with long-term safety, that the flexibility provided would be unlikely to be exercised in the real world, and that sufficient flexibility to meet public concerns could be achieved through a staged process of decision making during siting of non-phased disposal. One member felt that if flexibility was a very strong concern, then long-term storage should be pursued, not phased disposal. Others felt that phased disposal attempts to strike a balance between reducing burdens on future generations and maintaining flexibility for a period of time, and that it had received majority support at the Citizens' Panels, from groups using the Discussion Guide, and in the Schools Project. It was argued that this reflected a strong public desire to start out on a path that would reduce burdens on future generations, at the same time as enabling an extended period of learning, confidence building and potential to pursue a better option if it became available, even though members believe there are real difficulties in accepting that phasing genuinely provides for both flexibility and removal of burden (see Chapter 15). However, for most of these members, a decision about whether to recommend geological disposal or phased disposal did not need to be taken now, but could involve further debate, including discussions with potential host communities during the siting process. This could empower local communities, increasing the prospect for successful implementation.

- An area of uncertainty uncovered by the debate on phased geological disposal concerned the reasons why some PSE consultees had expressed a preference for this option. If their primary concern was to provide the ability to retrieve the waste, then this desire might be best served by storage rather than disposal. The Committee agreed that clarification of the reasons for preferring phased geological disposal would be a suitable issue for the final round of PSE.

- The role of storage in any UK strategy was discussed. Members preferring forms of geological disposal saw an important role for storage options as part of an overall strategy. As an integral part of a long-term management strategy, storage could help to manage uncertainties in the timetable for implementing disposal, or act as a fall back should the implementation of disposal fail. As pointed out by security specialists during the multi-criteria analysis, there was a need to review security vulnerabilities associated with current storage arrangements and, potentially, to enhance interim arrangements in some instances.

Comparison of multi-criteria and holistic assessments

39. In accordance with the Cooperative Discourse Methodology, members then compared the MCDA and holistic assessments, noting the consistency between the two, and discussing the reasons for any inconsistencies. The main points noted were:

- There was consistency between the provisional preferences of the majority of members for some form of geological disposal for most waste categories, and the outputs of the multi-criteria analysis.

- Those members who stated a preference for geological disposal did so having expressed confidence in the long-term safety of geological disposal. This judgement was consistent with the high scores given to the long-term safety of geological disposal by the safety specialists in the MCDA.

- The absence of support for long-term stores with current standards of protection, as a long-term management option, was consistent with the outputs of the multi-criteria analysis, where those options had the lowest ranking.

- In the holistic assessment, members gave significant support for local, shallow disposal on the assumption that the sites involved would not be subject to coastal erosion. There was consistency between this view and part of the MCDA outcome, which also ranked local, shallow disposal options highly. However, the MCDA also ranked geological disposal highly for Reactor Decommissioning Waste (RDW), in contrast to members' holistic views. However, the basis of the two assessments was not identical as specialist scores assumed that coastal erosion could be significant. It was acknowledged that preferences for some form of on-site disposal were driven by a desire to reduce the transport of waste. Members realised that what was not known was the balance of opinion between willingness to accept a local shallow disposal facility and willingness to accept transport of waste away from the site. This was an area where the NDA was already heavily involved, especially in its consultation on local site end states.

- The small but significant level of potential preferences for boreholes for plutonium and spent fuel was not consistent with the multi-criteria rankings, which placed the option third, significantly behind the other geological disposal options. It was recognised, however, that this was driven by a low score for implementability because the technology for boreholes was still developing and that they could become a more important element in the future.

- The importance attached to flexibility in discussions about the relative merits of storage and different forms of geological disposal in the holistic assessment may at times be much greater than the weight accorded to it in the multi-criteria analysis. In the latter case, the weight accorded to flexibility would have to be increased to approximately 35% of the total weight accorded to all criteria in order for storage options to rank higher than geological disposal.

40. The purpose and result of the multi-criteria and holistic options assessment was to identify which options performed best in which circumstances. CoRWM then needed to identify the best combination of options, taking account of all waste streams and covering the timescales over which geological disposal or interim storage would need to be implemented. The way that this was done and how it led to the final recommendations is the subject of Chapter 12.

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Chapter 12 How CoRWM reached its recommendations

During the final stage of its process, CoRWM brought together the various strands of its work to produce its final recommendations. This chapter shows how CoRWM's strategy evolved through a series of key decision making meetings to produce the set of integrated recommendations on options and implementation to present to Government.

1. CoRWM's decision making process was developed over a period of two and a half years (November 2003 to March 2006) and has been described in the preceding chapters. During that time the Committee considered the existing scientific and technical knowledge (Chapter 8) both in the UK and overseas (Chapter 9); undertook an intensive public and stakeholder engagement programme in three phases (Chapter 7); conducted a series of bilateral meetings with key stakeholders, governmental, regulatory and other bodies; developed a Multi Criteria Decision Analysis with input from specialist panels (Chapter 11); undertook an holistic assessment (Chapter 11); articulated its thinking on ethical issues (Chapter 6); and developed ideas on how its eventual proposals could be implemented (Chapter 17). By the Spring of 2006 the Committee reached the point where its wide-ranging considerations needed to be brought together in formulating its final recommendations for reporting to Government at the end of July 2006.

2. From the outset it had been recognised that CoRWM had been presented with an important but difficult task and should take responsibility for the final recommendations. The intention was to achieve a consensus among members if at all possible. This does not necessarily mean complete agreement or unanimity, rather an agreement to support a set of recommendations. Given the diversity of perspectives about the issue of radioactive waste in society at large, and within the Committee itself, the task was likely to prove challenging. To achieve what CoRWM's Guiding Principle 5 calls a 'conclusive process' it would be necessary to ensure that the range of viewpoints had been covered and all conclusions were effectively justified.

3. The decision making leading to CoRWM's final recommendations took place over a period of five weeks during March/April 2006 in a series of three plenary meetings (three days, two days and three days respectively) held in public with a private preparatory meeting (two days) in between. At the first of the plenary meetings, held in Brighton,[1] the Committee undertook its MCDA and the outcome of this is reported in Chapter 11. The second plenary in Edinburgh[2] was devoted to an holistic assessment and comparison with the MCDA. The outcome of this concludes the previous chapter. This present chapter, beginning with the third decision making meeting, also held in Brighton,[3] sets out how CoRWM reached its decisions. It also shows how the set of recommendations were developed and refined as a consequence of PSE4 and discussion of key issues. Two issues in particular stimulated continuing debate. One was the question of whether and to what extent phasing should be built into geological disposal. Another was to consider the role and significance of interim storage. A third issue, which emerged relatively late, was how to deal with Reactor Decommissioning Wastes (RDW). The debates on these issues are considered at various points in this Report. Here, the concern is with how these issues were resolved.

4. At the conclusion of the second plenary in Edinburgh, Committee members had indicated their provisional preferences in respect of different waste streams. These are summarised in the previous chapter. Broadly, there was a general preference for geological disposal for most waste streams with a minority

favouring interim storage. There was minority support for boreholes for wastes containing plutonium and a variety of views on the best ways of managing RDW. At this point preferences were indicative, not definitive, though there were different degrees of commitment to specific options among members. The next, and crucial, stage was to translate these tentative preferences into draft recommendations.

5. CoRWM approached its final decision making in two ways, initiated at a preparatory private meeting held at Meriden before the third decision making public plenary in Brighton.[4] The first was to consider how far options for different waste streams might be combined to provide management routes for a variety of wastes. A small group of members had been working on issues surrounding option combinations for several months and had prepared background material on factors that would affect option combinations. When at Meriden members reviewed this work and considered how option combinations might be feasible across waste streams, it became clear that combinations of this kind would be unlikely to be attractive for the great majority of wastes in the inventory, the relatively less significant waste stream of RDW being the only possible exception. For all other waste streams it seemed more likely that CoRWM would recommend pursuit of either one of the storage options or one of the geological disposal options. This Option Combinations approach clarified a number of issues.[5]

6. Taking storage options first, current methods of storage were not favoured. In response especially to security concerns, enhanced storage was preferred as an end point for a minority of members and also possibly for centralised interim storage of spent fuel. The need for storage in the event of failure of a repository programme was recognised. In terms of disposal options, geological disposal was widely supported on grounds of long-term safety and ethical perspectives on intergenerational equity, although it was recognised that social and political concerns would necessitate a staged process of implementation. The option of Phased Geological Disposal (PGD) had attracted considerable support from the public and stakeholders for its apparent ability to deliver flexibility while reducing burdens on the future. Consequently it was an option that must be considered on grounds of public acceptability. Boreholes attracted support from some members for their potential ability to provide isolation of the most hazardous wastes. Lastly, a number of possible variants for managing RDW were recognised but, at this stage, no firm conclusions were reached.

7. The Option Combinations approach prepared the ground for final decision making by identifying the parameters for decision making in terms of the options that were realistically available. But the exercise did not indicate how the different possibilities could be brought together nor identify the grounds on which a consensus might be constructed. For this, a second approach proved necessary. This was to develop a ‘strategy’. At the Meriden meeting one member tabled a so-called ‘Rough Strategy’ (see Box 12.1). Essentially this was designed to provide an integrated set of proposals that took into account the different perspectives of members but to which all might subscribe. The strategy proclaimed geological disposal as the ‘best approach’ within ‘our present knowledge’ but also recognised there were social and ethical concerns surrounding the method. In addition, it was very clear that it would take many decades to implement geological disposal. Consequently, in order to build trust in the approach, there would need to be a commitment to interim storage, the need for continuation of research into alternative methods of management and a continuing public and stakeholder engagement programme. A staged process of decision making would also be necessary.

Box 12.1 Rough 'Strategy'

1. At the present time and with our present knowledge CoRWM considers deep geological disposal to be the best approach for the long-term management of the UK's high level wastes.
2. Therefore, we recommend that the government proceeds to a process of staged implementation which will lead ultimately the deep disposal of high level wastes.
3. However, we also recognise that there are social and ethical concerns surrounding deep disposal sufficient to prevent a societal consensus in its favour at the present time.
4. We also recognise that the process of implementation of deep disposal will inevitably take a long time, possibly one or two generations before emplacement of wastes can begin.
5. Therefore, we recommend a staged process of implementation consisting of the following elements:
   a. a commitment to ensuring the safe and secure storage of wastes during the interim period before emplacement in a repository
   b. a continuation of research into alternative (i.e. additional to geological and long term interim storage) methods for the long-term management of radioactive wastes
   c. a continuing public and stakeholder engagement process aimed at building trust and confidence in the proposed long-term management approach
   d. a set of decision points providing for a review of progress with an opportunity for re-evaluation before proceeding further

CoRWM considers that an essential precondition to successful implementation will be the achievement of societal consensus, that is, sufficient agreement to proceed

8. The Options Combinations and Rough Strategy approaches formed the basis for discussions on the preferred strategy at the third decision making plenary at Brighton in April 2006. The meeting also considered a draft Implementation Report which had been prepared by a Working Group over the previous nine months. That Report [6] accompanies this one, and a summary is presented as Chapter 17 of this Report. The implementation proposals, following CoRWM's Guiding Principles, focussed on achieving intra-generational equity in the siting of radioactive waste facilities. The key proposals were: community involvement should be based on a willingness to participate as well as a right to withdraw; participation should be developed through partnerships expressing an open and equal relationship between a host community and the implementing body; packages should be provided for partnerships to support participation in both the short and long term; and important decisions should be ratified by the appropriate democratically elected body/bodies. In general, these proposals, as well as the more detailed recommendations in the full Implementation Report, carried the support of the full Committee. There were a number of important issues that required further debate and development as part of the implementation process which would follow the Government's response to CoRWM's proposals. But it was agreed that the key recommendations on implementation, as outlined above, should form an integral part of the package of proposals to be put to Government in July 2006.

9. The Brighton decision making meeting was presented with a Draft 'Strategy' comprising a slightly amended Rough Strategy and the key proposals for implementation. During the course of debate over two days, this strategy was further amended and developed. In particular, there were amendments proposed by one member which sought to question the confidence in disposal and to strengthen the role of interim storage. Some reorientation of the proposals was made as a result. Another member offered a series of detailed amendments, some

of which were incorporated. The whole Committee debated the set of proposals clause by clause in coming to its final recommendations.

10. The main points emerging from the discussion of the Draft Strategy were as follows:

- The choice of disposal should be justified by reference to its being the best available option when compared with the risks associated with other options.

- In emphasising the role of interim storage, members felt that there was a need to stress the issue of the time taken to implement geological disposal as well as the uncertainties, technical, social and ethical, that might be associated with the approach.

- The proposals for interim storage needed strengthening to take account of security concerns, packaging, and avoiding unnecessary transport of wastes. There was a need to strengthen the commitment to research on storage and disposal as well as keeping open the possibility of alternative methods.

- The proposals for implementation were generally supported, though some detailed amendments relating to clarification and emphasis were made. It was recognised that there were issues that would need to be further considered during the implementation process itself. Among these were: the definition of 'community'; the relationship between communities, partnerships and democratically elected bodies; the composition of partnerships; how and by whom invitations to participate are issued; who has the right to withdraw and when the right can be exercised. Some of these matters were considered further during PSE4 and by the Committee.

- There was one area, absent from the Draft Strategy, which exposed fundamental differences among the members. This was the issue of repository design, more especially whether there should be provision to leave the repository open for several hundreds of years after emplacement of the wastes (often referred to as 'phased disposal', but see Chapter 15 for discussion of definitions) and, if so, who should take the decision. This debate is rehearsed at various points in this Report, notably in the Overview, in Chapter 6 and in the following Chapter 13. Basically, one group of members felt CoRWM should take the responsibility and recommend in favour of closing the repository as early as possible; not to do so amounted to avoiding the issue and placing a burden on future generations. Another group felt strongly that the views of PSE should not be lightly set aside and that potential host communities should have a role in decision making about the form of geological disposal.

11. On this issue it proved impossible to reach agreement. Accordingly, it was agreed to add a further paragraph indicating that the form of geological disposal should be a matter for debate in the ensuing round of PSE.

Box 12.2 Draft recommendations agreed by CoRWM on 27 April 2006

Since 1997, there has been a vacuum in UK policy on the long-term management of long-lived and more highly active radioactive wastes. CoRWM has drafted the following integrated package of recommendations. This is the start of a process, leading to CoRWM's final recommendations. Once made, they should be acted upon urgently.

1. Within the present state of knowledge, CoRWM considers geological disposal to be the best available approach for the long-term management of all the material categorised as waste* in the CoRWM inventory when compared with the risks associated with other methods of management.

2. CoRWM recognises that there are social and ethical concerns that might mean there is not sufficient agreement to implement geological disposal at the present time. In any event, the process of implementation will take several decades. This period could last for as long as one or two generations if there are technical difficulties in siting or if community concerns make it difficult, or even impossible, to make progress at a suitable site.

3. These uncertainties surrounding the implementation of geological disposal lead CoRWM to recommend that a programme of interim storage is required as a contingency and therefore must play an integral part in the long-term management strategy.

4. Therefore, CoRWM recommends a staged process of implementation, incorporating the following elements:

    a. A commitment to the safe and secure management of wastes through the development of an interim storage programme that is robust against the risk of delay or failure in the repository programme. Due regard should be paid to:

        - reviewing and ensuring security, particularly against terrorist attacks;
        - ensuring the longevity of the stores themselves;
        - minimising the need for re-packaging of the wastes; and
        - addressing other storage issues identified during CoRWM's public and stakeholder engagement process, such as avoiding unnecessary transport of wastes.

    b. A commitment to an intensified programme of research and development aimed at reducing uncertainties at a generic and site-specific level in the long-term safety of geological disposal, as well as better means for storing wastes in the longer term. Appropriate R&D should be undertaken into alternative management options.

    c. A commitment to ensuring that flexibility in decision-making within the implementation process leaves open the possibility that other long-term management options (for example, borehole disposal) could emerge as practical alternatives.

    d. A continuing public and stakeholder engagement process aimed at building trust and confidence in the proposed long-term management approach, including the siting of facilities.

Box 12.2 Draft recommendations agreed by CoRWM on 27 April 2006 (continued)

e. A set of decision points providing for a review of progress with an opportunity for re-evaluation before proceeding to the next stage, or before foreclosing alternatives.

5. CoRWM has not yet decided whether to make recommendations regarding the precise form of geological disposal. This will be an element in the next round of public and stakeholder engagement.

6. If a decision is taken to manage uranium, spent nuclear fuel and plutonium as wastes, they should be added to the inventory and immobilised for secure storage followed by geological disposal. There must be clarity about the inventory that is to be disposed of by the time that communities are invited to express a willingness to participate in the implementation process (see below). Any additions to that inventory should be the subject of an additional stage in the process.

7. Community involvement in any proposals for the siting of long term radioactive waste facilities should be based on the principle of volunteerism, that is, an expressed willingness to participate. Participation should be based on the expectation that the well being of the community will be enhanced.

8. Willingness to participate should be based on the provision of community packages that are designed both to facilitate participation in the short term and to ensure that a radioactive waste facility is acceptable to the host community in the long term.

9. Community involvement should be achieved through the development of a partnership approach, based on an open and equal relationship between the potential host community and those responsible for implementation.

10. At the end of each stage of the decision making process there should be provision for a review and the right of communities to withdraw from the process before proceeding to the next stage, up to a pre-defined point.

11. In order to ensure the legitimacy of the process, the key decisions at each stage should be ratified by the appropriate democratically elected body(ies).

12. CoRWM considers that an open and transparent process is an essential precondition to successful implementation of these recommendations.

CoRWM takes no position on the desirability or otherwise of nuclear new build. We believe that future decisions on new build should be subject to their own assessment process, including consideration of waste. The public assessment process that should apply to any future new build proposals should build on the CoRWM process, and will need to consider a range of issues including the social, political and ethical issues of a deliberate decision to create new nuclear wastes.

12. The discussions and consequent amendments were incorporated into a ‘Draft for Decision’ which was put to the members on 27 April 2006. It was endorsed by the whole Committee with one member indicating ‘fundamental concern that the long-term safety of geological disposal, that underpinned the draft recommendations, had not been sufficiently demonstrated’.[3] The agreed recommendations are set out

in Figure 12.2. It was agreed that rationales should be developed for each of the recommendations and that they should be presented for comment to a further round of PSE.

13. CoRWM had taken its main decisions at the third decision-making plenary at Brighton. The recommendations represented a synthesis of knowledge, experience, values and understanding developed over the course of the CoRWM process. They also reflected an integration based on deliberation, negotiation, compromise and consensus achieved by the members. Once drafted it was unlikely that the recommendations would be subject to fundamental change. However, there were some issues, notably the form of disposal, that were open to further debate. And, in view of the importance of PSE to the whole process, it was felt important that opportunity should be given for a final round of comment, this time on the proposals themselves to which the public and stakeholders had contributed. In addition, comments (for clarification) would be sought on the MCDA/holistic processes. PSE4 would also provide a first opportunity to gather comments on CoRWM's draft implementation proposals.

14. The main outcomes of the PSE4 round have been presented in Chapter 7 and specific detailed comments are contained in the reports of the Citizens' Panels, stakeholder meetings, website responses and bilateral meetings with key organisations and institutions. A brief account of the main responses is given here. Most stakeholders and citizens were supportive of the draft recommendations. Although environmental groups supported many elements in the package they were mostly opposed to the proposed end point of geological disposal. Many participants felt that the recommendations should be seen as an integrated package and support would diminish if specific elements were 'cherry picked' by the Government or an implementing authority. The emphasis on flexibility and management of uncertainties was welcomed.

15. On the issue of the form of geological disposal, most participants wanted CoRWM to say more about its own thinking, though they did not want the Committee to make prescriptive recommendations. Another area where clarity would be welcome was whether the proposed implementation measures would also apply to interim storage arrangements.

16. There were also observations on how CoRWM could build further confidence in the recommendations. These included: clarifying and justifying the timescales on implementation; encouraging good practice in the interim management of wastes; identifying what steps could be taken to ensure that disposal would not be 'out of sight, out of mind'; considering communities affected by proposals as well as host communities; recommending a central role for an independent overseeing body that is open and transparent and committed to public and stakeholder engagement; and emphasising that the recommendations should address currently committed wastes and not those that might arise from any new build programme.

17. Overall, there appeared to be widespread satisfaction with the way CoRWM had reached its recommendations as is evident from the comment in Box 12.3.[7]

Box 12.3 Comments on the recommendations

'All groups expressed confidence in the twelve draft recommendations as a whole package. The recommendations addressing implementation issues were seen as essential to the success of the recommendations addressing options. It was considered that CoRWM had conducted a legitimate decision-making process, resulting in a sound set of draft recommendations, and that appropriate account had been taken of input from Citizens' Panels. CoRWM was seen as having set high standards of openness and transparency through its public and stakeholder engagement processes. It was considered important that these ideals and practices should be continued into and throughout the implementation phases. It was thought that an independent body, like CoRWM, should be formed to oversee the implementation process'.[7]

18. As a result of PSE4, CoRWM again debated the form of geological disposal rehearsing by now familiar arguments.[8] While there was general agreement favouring early closure of a repository, the Committee remained divided on the question of whether to make early closure a recommendation. Those favouring early closure argued that CoRWM should stand by its conclusion that keeping a repository open for several hundred years would impose burdens on future generations and a safety case might be hard to achieve. Other members considered phased disposal should not be ruled out particularly in the light of the PSE response. Leaving the issue open would be in the spirit of participation emphasised throughout the process. It was eventually agreed that CoRWM would make no specific recommendation on the form of disposal. Instead, it would indicate its unanimous preference for early closure whilst recognising the debate would continue.

19. PSE had also supported the role of interim storage both as an integral element in the strategy and as a contingency in the event of failure of the repository programme. A range of detailed points had been made in reference to the generic recommendations on storage, covering such issues as the longevity of stores, the need to achieve passive safety and the desirability of avoiding unnecessary transport of wastes. Whilst recognising the role of the NDA in relation to storage on many nuclear sites, the Committee discussion of the PSE responses led to a more detailed development of its recommendations on interim storage (see Chapter 16). The discussions raised issues about the siting of stores, notably whether they should be central or dispersed at existing local sites. This introduced a conflict between the desire to minimise transport (dispersed locations) and the need to secure public acceptability (possibly more difficult to achieve at a number of sites as the failure to find sites for LLW in the 1980s had demonstrated). The recommendations on stores emphasise that they should be designed to avoid major refurbishment or replacement for the period up to emplacement of wastes in a repository, and should also be able to withstand terrorist attack over this period. There are also recommendations on interim storage for different waste streams, notably the possibility of a central store for spent fuel and secure arrangements for the storage of plutonium if it were to be declared a waste.

20. The final issue to be resolved on management options concerned RDW. The short lived ILW and LLW not suitable for disposal at the LLWR was only a small part of CoRWM's inventory. There were a number of possibilities for this waste, including: co-disposal with the remainder of CoRWM's inventory in a geological repository; or co-disposal with LLW in shallow facilities at existing or new sites (if these facilities were developed following the LLW Review). The Committee agreed to

introduce a facilitative recommendation on RDW which indicated the need to consider available management options.

21. The proposals for implementation secured general agreement among the Committee members. There were three reasons for this. One was the general support for the proposals from stakeholders and the public who had been involved in discussion and responded to the proposals. A second reason was the widespread recognition that, given past failures at siting, there was a need for a fresh start based on co-operation and community participation. Third, the proposals in the main presented a process rather than a set of definitive recommendations. They offered the prospect of further debate, clarification and refinement as the implementation process got under way. The PSE4 responses emphasised the need for implementation to be seen as part of a whole and indivisible package, and urged the setting up of an independent overseeing body without delay. There was a very strong message that the Government should continue the momentum achieved by CoRWM.

22. In reaching its recommendations CoRWM had fulfilled its terms of reference 'to recommend the option, or combination of options, that can provide a long-term solution, providing protection for people and the environment'. It had done so, as required, in an open, transparent and inclusive manner. It had engaged with the public and stakeholders throughout. Moreover, it had also pointed the way forward indicating to Government the steps that need to be taken to implement its proposals. The Committee had achieved consensus on the recommendations and had met its commitment to report to Government by July 2006.

References

1 Committee on Radioactive Waste Management, " Minutes of Plenary Meeting, 28-30 March 2006, Brighton", document number 1680, 2006

2 Committee on Radioactive Waste Management, " Minutes of Plenary Meeting, 11-12 April 2006, Edinburgh", document 1705, 2006.

3 Committee on Radioactive Waste Management, " Minutes of Plenary Meeting, 25-27 April 2006, Brighton", document 1724, 2006.

4 Committee on Radioactive Waste Management, " Summary of 18-19 April 2006 meeting", Document no. 1714, 2006

5 Committee on Radioactive Waste Management, " Combination Table": Annex 1 to Document no. 1714, 2006

6 Committee on Radioactive Waste Management, "Moving forward: CoRWM's proposals for implementation", CORWM document 1703, 2006.

7 Lancaster University, "CoRWM Public and stakeholder engagement phase 4, Citizens' Panel (Third Meeting) Report", CORWM document 1750, 2006.

8 Committee on Radioactive Waste Management, " Minutes of Plenary Meeting, 23-24 May 2006, Leeds", CORWM document 1742, 2006; and in private sessions to discuss the drafting of this Report.

Chapter 13 Confidence in geological disposal

To determine its recommendations, CoRWM needed to decide whether or not it had sufficient confidence in geological disposal to consider making this option a part of its overall package of recommendations. This chapter sets out arguments for and against geological disposal derived from ethics, overseas experience, PSE and science.

Introduction

1. Chapter 12 describes the process by which CoRWM reached its recommendations, but only in part deals with their substance. To determine its recommendations, the Committee needed to make a decision on a major and controversial area in radioactive waste management policy – namely whether or not CoRWM had sufficient confidence in geological disposal to consider making this option a part of its overall package of recommendations. To make this decision, CoRWM considered all the relevant streams of knowledge that it had gained, deriving from ethics, overseas experience, public and stakeholder engagement and science. This chapter considers each of these in turn and shows how they were combined to contribute to the substantive recommendations described in Chapter 14. It sets out the arguments for and against geological disposal as the end point of strategy.

Ethics

2. The long-term safety of geological disposal matters because of ethical concerns over the impact of radioactive waste on future generations. Consequently, ethics were an important component in the CoRWM decision as to whether or not there could be sufficient confidence in geological disposal (Chapter 6). The critical issue that emerges from ethical deliberation is ‘deal with it now’ or ‘leave it till later’. This is based on the ethical idea of fairness between generations (intergenerational equity). The difficulty lies in knowing how to achieve this fairness.

3. The ethical consideration behind dealing with it now is that it is the responsibility of the present generation, which has used nuclear energy, to deal with the waste created as soon as it can. The objective here is to minimise the burden facing future generations. A decision on how this can best be achieved will be greatly influenced by the confidence that is placed in the long-term safety of geological disposal. If there is high confidence that geological disposal genuinely removes burdens from future generations then the disposal option is likely to be the favoured way of dealing with it now. If there are doubts about the ability of geological disposal to remove these burdens, then dealing with it now would lead to a commitment to getting the waste into safe storage as soon as possible and to researching better methods of finding long-term management routes.

4. The ethical consideration behind leaving it until later is that it enables the current generation to avoid constraining the choices facing future generations. This is important because it is impossible to predict the needs and aspirations of future generations. There is also an ethical argument that it is wrong to lose control over hazardous material irrespective of long term safety and environmental expectations. Storage might provide a safe method of managing the waste in the interim while maintaining flexibility for the longer term so that future generations can make their own decisions. Geological disposal can also provide a degree of flexibility up to the point of closure.

5. From this brief discussion it is evident that a variety of ethical principles may apply to questions of 'dealing with it now' or 'leaving it till later'. Although some ethical positions can in isolation lead more or less directly to a pro-storage or pro-disposal preference, others do not. The preferred option may significantly depend on a judgement about the degree of confidence held in the long-term safety of geological disposal or continuing institutional control, and on the ethical stances adopted by the individual.

Overseas experience

6. Overseas experience (reported more fully in Chapter 9) was another ingredient in the decision-making process about geological disposal and storage. There is a clear dichotomy between experience and intention in the overseas experience of managing radioactive waste. In the 60 year history of waste management, experience is more or less exclusively of storage of various kinds. There is an operating geological repository in New Mexico (Waste Isolation Pilot Plant - WIPP) for military-origin wastes, and although a facility at Konrad in Germany has been licensed, there is no currently operating civilian radioactive waste repository. While the history of storage has been mixed and early storage practices fell far short of current safety standards, radioactive waste storage has generally been safe. Even though the kind of extended storage envisaged by proponents of storage is not yet tested (for example, the need for store refurbishment and major waste re-packaging), the pro-storage argument emphasises that little new technology is needed and that storage is established and safe practice. Geological disposal by contrast is as yet broadly untested.

7. However, in those countries that have made firm decisions on long-term waste management strategy, all have decided that geological disposal is the best way forward. In the case of Finland, there has been a start on a repository at Olkiluoto and in Sweden two communities are willing to host a proposed geological disposal site. In addition, the NWMO in Canada has recently recommended geological disposal as the best long-term option for managing spent fuel. The Netherlands is a partial exception to these decisions in favour of geological disposal. Its decision is to store for 100 years and then move to geological disposal when enough funds, and wastes, have accumulated. The pro-disposal argument puts weight on this dominant acceptance internationally of geological disposal as a future strategy and emphasises the risk that institutional control may be lost.

Views of the public and stakeholders

8. CoRWM gave much weight to its engagement with the public and stakeholders (PSE - see Chapter 7). While the Committee was always explicit that it would make its own decisions on which option or options to recommend, and would not simply act as a conduit for any particular view expressed, citizen and stakeholder views remain of great importance. If CoRWM contemplated recommending an option in the face of widespread public and stakeholder hostility, the chances of implementation would clearly be negligible. This section therefore considers what CoRWM learned about public and stakeholder views on this subject, as one part of its decision making process.

9. Within responses from citizens, the views of Citizens' Panels are especially interesting, because participants had more opportunity to acquire a deeper grounding in relevant issues than any other groups. The Panels provided a good understanding of the range of views that would exist among the general public (Chapter 7). The majority view of the Citizens' Panels was that some form of geological disposal should form part of the overall strategy. The CoRWM Schools projects, which had important but less extensive deliberative elements, also

delivered a strong opinion in favour of disposal. A large majority of those who used the Discussion Guide also favoured disposal.

10. Stakeholder views were more mixed, although a majority of stakeholders also expressed approval for geological disposal. Among the various 'sectors' of stakeholders the following groups all favoured disposal as end-point: regulatory and advisory agencies – the Environment Agency, Scottish Environment Protection Agency and Health Protection Agency; the nuclear industry; substantial sections of local government; trades unions; and learned societies and professional bodies. The views of environmental NGOs sharply contrasted with those above. Greenpeace, Friends of the Earth Scotland, and the Welsh Anti-Nuclear Alliance strongly opposed geological disposal.

11. The interpretation given to the preferences expressed in the three main deliberative processes, i.e. the Citizens' Panels, the Discussion Guide and the Schools Project, was considered carefully by CoRWM. The choices made by members of the public were not starkly between geological disposal and storage. Participants were invited to express more detailed preferences: between geological disposal, meaning early closure of a repository; phased geological disposal, delaying potential closure by up to 300 years; and variants of interim storage. Phased disposal appears to offer both the advantage of removal of burden through early action and flexibility through the possibility of gaining access to wastes over relatively long periods. The question is then whether citizens who preferred phasing were more influenced by the possibilities of flexibility and retrievability (also offered to an even greater extent by storage) or whether they were more influenced by the idea that phased disposal represented early action that was intended to lead to disposal (also offered by geological disposal). It is also likely that they were attracted by the prospect of getting the 'best of both worlds' - of flexibility and removal of burden - even though in practice the attractiveness of phasing, as discussed in Chapter 15, is less than it first appears.

12. There is almost certainly no definitive answer to these questions. One interpretation, supported by one member of CoRWM, is that a preference for phasing amounted primarily to wanting retrievability. If the preferences for storage and phased disposal are added up, then in each of the three citizens' deliberative activities, 61%, 61% and 58% respectively wanted retrievability.[1] Storage options also provide flexibility and retrievability, and more effectively than phased disposal. On this view, then, citizens showed majority support for options with characteristics best displayed by storage. However during PSE4, citizens were able to review this issue and they appeared to confirm that their preference was indeed for some form of disposal.

13. Another interpretation, supported by several other members of CoRWM, is that in prefering phased geological disposal or geological disposal, members of the public were supporting early action to build a repository to one kind of detailed design or other. Citizens had the opportunity to opt for storage if flexibility was uppermost in their minds, and a minority chose to do so. If preferences for the three disposal options (including boreholes) are added up, then in the same three citizen processes between 60%, 63% and 97% wanted geological disposal. On this interpretation a majority of citizens do want early action involving geological disposal of one type or another.

14. The precise proportions shown above are not important. Public views on long-term management options show considerable subtlety and it is impossible to capture all the nuances involved in the process by which they expressed preferences between options. There is a continuum of opinion between the desire to maximise flexibility on the one hand and the desire to remove burdens from future generations as quickly as possible on the other. Most CoRWM members, while recognising this continuum, nevertheless were persuaded that a significant

majority of those members of the public with whom CoRWM engaged were in favour of moving towards geological disposal of one kind or another as soon as practicable. Most members of CoRWM therefore concluded that there would be a basis for public confidence if geological disposal was part of its recommendations.

Specialist opinions: the CoRWM MCDA

15. An important test of confidence in geological disposal for CoRWM's decision making process was the expected safety and environmental performance of geological disposal over the very long-term.

16. The first way in which CoRWM assessed this was through its MCDA. The overall MCDA result, combining specialist performance assessments and weighting of assessment criteria (see Chapter 11) showed the two main geological disposal options as ranking well ahead of all the storage options. It needed a very large set of changes in both performance measures and weights in a systematic pro-storage direction for the storage options to reach parity with disposal. In this sense, the MCDA produced a robust outcome in favour of disposal across eleven different assessment criteria even if the application of some criteria, especially burden on future generations and flexibility, is the subject of some controversy (see Chapter 11).

17. But MCDA has limitations and cannot provide 'answers' to questions of choice between options. Analysis of the overall MCDA results by relevant criteria shows the degree of confidence that specialist opinion, as used in the MCDA, had in geological disposal. For long-term confidence, the key criteria for performance assessment are public safety and environmental performance.

18. For public safety in relation to radioactivity, the results were that geological disposal options were rated in the range 'very strong' to 'inherently resilient' to possible adverse events in the period up to 300 years into the future. For storage options in the period up to 300 years, the rating was that they would provide intermediate resilience to adverse events but contained some weaknesses, partly due to the need to refurbish stores and repackage wastes, increasing worker exposure to radiation. For the period beyond 300 years, geological disposal options were expected to provide very high confidence in their ability to protect the public against radiation for all waste streams except ILW, where confidence was high, rather than very high, mainly due to uncertainties about the potential gas pathway for radionuclides to the biosphere.

19. In the case of environmental protection from radiation (in other words, for non-human species), the expectation of the specialists was that for the first 300 years geological disposal options would provide between very strong and inherent resilience while storage options would give poor resilience. In the long-term, beyond 300 years, it was expected that geological disposal options would provide high to very high confidence that radiation releases to the biosphere would be minimised.

20. Overall, for the period up to 300 years, where direct comparison between geological disposal and storage options was possible, the geological disposal options were expected to give better safety and environmental protection than storage options. For the period beyond 300 years, confidence in the performance of geological disposal was high or very high.

21. Even though the overall MCDA result and the performance assessment within it of safety and environment suggested a high degree of confidence in geological disposal, and higher than for storage, a pro-storage case can nevertheless still be constructed from the overall MCDA. On some assessment criteria, especially

flexibility, storage options performed better than disposal. If flexibility is weighted high enough relative to all other criteria, storage options would, overall, be rated higher than some disposal options in the MCDA. Wider pro-storage arguments set great weight on flexibility, often because of a belief that the irreversibility of disposal denies future generations the right to choose how to protect themselves against radiation exposure at levels they may find unacceptable. The pro-disposal argument would instead place significant weight on the higher safety scores for disposal than storage, the better security scores for disposal on most security criteria and the much higher disposal scores for ‘burden’ (effectively, removal of burden). More generally, the pro-disposal argument is that geological disposal minimises the period into the future when institutional control is required to ensure safety and security, and believes it unwise to rely on a continuation of the high levels of institutional control several hundreds of years into the future.

22. But the burden criterion is contentious. Scoring geological disposal options high in burden terms effectively amounts to a high degree of confidence in the long-term safety of geological disposal, and the pro-storage argument is sceptical of such claims. For further insight into the very important issue of confidence in long-term safety of geological disposal CoRWM turned to an assessment of the nature and credibility of evidence from the wider scientific community.

The wider science community’s views and challenges to those views

23. To assess confidence in the safety and environmental performance of geological disposal, CoRWM sought knowledge from as wide a range of scientific expertise as possible. The MCDA specialists believed that a high level of confidence was justified, but these specialists – while a distinguished group of scientists – were necessarily a limited sample and did not include representation from the NGOs. CoRWM needed to collate evidence from a much wider range of sources on this subject. There are a number of general issues to be considered first.

24. The first issue is that of potential bias. Much of the international scientific community’s work in this area has been carried out within, or under contract to, organisations which are pre-disposed towards nuclear power – for example the Nuclear Energy Agency of the OECD (NEA) and the International Atomic Energy Agency (IAEA). These organisations have consistently expressed their own confidence in the long-term safety of geological disposal.[2] Within the UK, a good deal of scientific expertise has resided within Nirex, the body - originally owned by the nuclear industry and now by Government - that has had responsibility for most of its life for finding suitable UK sites for geological disposal of ILW. It too has often expressed a high level of confidence, especially in relation to its own preferred design for a phased repository, capable of staying open after emplacement of waste for several hundred years.[3]

25. The fact that scientific expertise is ‘owned’ by such bodies can cause suspicion of bias, but it does not necessarily invalidate the views expressed by those scientists. Their institutional affiliations must be noted and considered, but the views expressed need to be tested in the same way as any scientific views and not automatically discounted because of institutional affiliation. But this also means that it is important to establish support or verification for such views from sources of expertise that are independent of such institutional interests. For these reasons, CoRWM canvassed opinion among members of the ‘learned societies’, which contain a significant number of distinguished and independent scientists and held meetings specifically designed to hear such opinion at first hand (for example the Royal Society November 2005 meeting, the Geological Society international event in January 2006) Bias can, of course, also in principle be present because of the institutional affiliations of those who work for anti-nuclear groups but, as above, this is not a reason for necessarily discounting any view expressed.

26. The second issue concerns the nature of the assessment that CoRWM had to make. The Committee is required to recommend generic options, not specific design concepts. Much detailed design work and investigation will be needed if geological disposal were to be pursued by Government. During such site investigation and design work it could become clear that any individual site is unsuitable for geological disposal for a variety of possible reasons. Many people in the earth sciences community expressed to CoRWM their view that while they had high generic levels of confidence in geological disposal, the suitability of any individual site could not be affirmed until much detailed site investigation had taken place. However, this is a question that later parts of the MRWS process would need to determine if geological disposal was pursued. It was never part of CoRWM's remit.

27. The third issue concerns uncertainty and its interpretation. Future events, even a few years hence, are inherently unpredictable, and for long-term radioactive waste management, the impacts of current decisions could be felt hundreds of thousands of years into the future. A substantial part of the argument between storage and disposal is about irreducible uncertainties in the long-term future. Modelling future behaviour of radioactive waste is an important component in assessing future safety levels and models have an important place in assessing overall confidence levels. However, it is impossible to have complete confidence in the precise predictions of such models. The pro-disposal argument is reassured by other less quantifiable indicators of confidence (see next paragraph). The anti-disposal view holds that knowledge about geological disposal is inadequate, so that delay in commitment to a disposal strategy is necessary until knowledge about long-term management options improves substantially .

What can confidence in long-term safety rest on?

28. In the context that sufficient confidence needs to be demonstrated over periods of up to a million years into the future, the main pro-disposal arguments are as follows:

- The design of a geological repository is a multi-barrier concept that can be fitted in detail to the particular (suitable) geology of a repository site, which can be crystalline rock, salt, shale or clay, all of which exist in the UK and underly over 30% of its area.[4] The waste form and packaging, the waste container, the 'backfill' material used and the geological suitability of the chosen site should all act to delay and retard the movement of radionuclides when, after a very long period, radioactivity escapes from the waste package and enters the geosphere.

- There is high confidence in the scientific community that there are areas of the UK where the geology and hydrogeology at 200 metres or more below ground will be stable for a million years and more into the future.

- Confidence in this expectation derives in part from a reconstruction of the historic records of geology in the UK and elsewhere. This work demonstrates that the geological structure of the UK at such depths has been stable for very long periods. Internal physical and chemical conditions in many such structures have been stable for many millions of years. Hydro-chemical processes that could lead to mobilisation of radionuclides would be extremely slow. The possibilities of disturbance from seismic or volcanic activity, or future climate change are, at such depths, negligible.

- Work on natural analogues show that geologies with a low water flow will retain radionuclides over very long periods. Natural analogue work in Canada and Gabon (the latter containing a 'natural nuclear reactor') suggests that even large events involving nuclear criticality have resulted in the movement of fission products only a few tens of metres through surrounding rock over very long periods.

- When a repository is excavated there is inevitably a perturbation in the local geosphere. Research on this issue suggests that the local geosphere will recover from its initial perturbation within a few hundred years and remain stable thereafter.

- There is consensus in the scientific community (including the regulatory community) that the forms of radioactivity most likely to display high mobility have been identified, together with the uncertainties associated with their mobility.

- After taking account of the various uncertainties that still exist, regulators have been satisfied that risk targets can be met in all countries where individual sites have been examined.

- If these risk targets were met, using ICRP assumptions about the relationship between radioactivity and health impact, the uncertainties associated with predicting the amount of radioactivity and the time that it would take to reach the biosphere would mean that the maximum level of radiation exposure (approximately 10 millisieverts per year to the most exposed members of the population[5)] occurring 200,000 years in the future, would not exceed natural background radiation levels in some parts of the UK today. Ten millisieverts is approximately five times greater than the UK's average natural background level. By contrast the 'most likely' case suggests a negligible human dose over the relevant period of several hundreds of thousands of years. The decay of radioactivity means that its potential for harm eventually reduces to natural background levels. In the case of HLW, this 'crossover' time is a few thousand years, though for spent fuel the period is much longer, of the order of 300,000 years.

- As a result of the combination of design and geology, it is therefore considered very unlikely that radioactivity will reach the biosphere in quantities large enough to cause significant harm to human or other populations even over many hundreds of thousands of years.

- The Health Protection Agency judge that the uncertainty in the ICRP dose factors (translation of radioactive dose into health consequences) is limited to a factor of less than two for the most potentially damaging radionuclides.

29. Those who are unconvinced of the above case for confidence in the long-term safety of geological disposal do not take the evidence on which it is based at face value. In the context of the need for confidence over a million years, they believe that the case is unverifiable and that this alone should rule out consideration of the option. They question the interpretation and application of evidence; whether or not all the assumptions are reasonable; and whether all relevant scenarios have been considered. Uncertainties are clearly manifold over so long a period into the future. Arguments against disposal include:

- there may be significant problems within the waste containers, involving gas build-up and relatively rapid corrosion of container cladding, thereby invalidating calculations about the rate at which radionuclides reach the biosphere.

- the materials expected to be used as backfill for repositories, for example cements and bentonite clay, may experience shrinkage or cracking respectively, thus accelerating both the ingress of water into the repository and the movement of radioactivity into the geosphere and biosphere, again invalidating modelling results. Assumptions about permeability, especially for some forms of backfill material, depend on extrapolations from existing data and may be unreliable.

- there may be poorly understood chemical and/or microbiological reaction or activity in relation to escaped radioactivity, for example on exposure to minerals and salts in the rock. Interactions between heat, water, radioactive decay, gas build-up and the presence of microbial organic matter are poorly understood, again potentially accelerating the return of radioactivity to the biosphere.

- both groundwater and gaseous pathways by which radioactivity may return to the biosphere cannot be fully understood and may again lead to acceleration in the process.

- the ability of the backfill material to trap sub-micron radioactive particles and the possibility of such particles returning to the biosphere has not been explored.

- the large-scale perturbations involved in constructing a deep repository may significantly undermine the high-quality geological conditions which underlay the original site selection by the creation of stress fractures and the resulting ingress of water to an area of low pressure created artificially. If the local geosphere does not return to a stable state as predicted in the pro-disposal argument, any of the above negative potential effects may be amplified.

- different waste types have differing technical requirements for ensuring safety and no generic safety case over a million years can therefore be made.

- in addition, it is impossible to know what future societies may learn about the impacts of radioactivity on human health. Radiological protection standards have become more stringent in the last 50 years and may become more so, especially if the human health effects of radiation are discovered to be more severe than currently understood. Future societies may also, quite separately from this argument, decide on much more stringent health and safety standards in respect of radioactive waste.

- the 'worst case' analyses quoted above depend on quantitative modelling that is necessarily highly uncertain and could easily be substantially wrong. If the Low Level Radiation Campaign (LLRC) were right that the health effects of given doses can in some cases be substantially more harmful than the International Commission on Radiological Protection (ICRP) suggests, the effects on human populations could well be substantially higher than modelling suggests.

30. The collective impact of these arguments is that while geological disposal aims to provide a means of 'concentrate and contain' for radioactive waste, it may end up as 'dilute and disperse', because even the pro-disposal models assume that some radioactivity eventually returns to the biosphere. Sceptics argue that comparing geological disposal against storage over 300 years is not relevant to the debate about safety and security up to a million years in the future. While support for disposal comes from the scientific community, overseas experience and public and stakeholder opinion, there remain doubts about the use of the ideas of 'burden' and 'flexibility' in pro-disposal arguments. Both sides believe that the opposite argument to their own represents a deferral of the problem.

31. The LLRC takes a different view about the dose/risk relationship to that of ICRP.[6] Work was carried out for CoRWM to test the effects of LLRC assumptions on the possible health effects associated with the 'worst case' described above. The first occasion that the implications of LLRC views were reported to CoRWM, the conclusion was that total risk, summed over all radionuclides, would rise by a factor of around two (from ten times the current regulatory dose limit to 20 times), compared to the worst case figures quoted above. However, LLRC subsequently presented, for uranium isotopes, much higher 'weighting' factors which would, if validated, increase risk by a factor of about 25. However the basis for these enhanced weighting factors has not yet been published (and so has not been appraised by the wider scientific community). Most members of CoRWM

do not therefore find these recent LLRC arguments convincing, especially in the light of the substantial weight of peer-reviewed evidence that points to very much lower doses. One member of CoRWM, however, believes that the LLRC views should be treated as potentially credible, arguing that the 'worst case' figures quoted above (five times the average UK natural background level) are themselves too great a risk to run. If the LLRC were to be right, the exposures of future populations would be much higher and this could make an strong case for caution and a continuation of interim storage while more evidence about radioactivity is accumulated.

32. There is no way in which the scientific debate between supporters and opponents of geological disposal can be definitively resolved now on the basis of incontrovertible evidence. There is an almost universal level of support among scientists in the UK and internationally that geological disposal is a sufficiently safe long-term option for managing higher-level radioactive wastes. This view is also taken by relevant regulatory and advisory agencies in the UK and internationally. But this is not definitive: neither side in the disposal/storage argument can 'prove' its case because in both cases, predictions are needed over either hundreds of years (storage) or hundreds of thousands of years (disposal). The anti-disposal case rests on doubts about the quality and reliability of evidence presented in favour of geological disposal. The pro-disposal case rests on a large amount of international scientific work, which generally regards the questions raised by the anti-disposal arguments as unlikely to shake the foundations of the disposal case together with serious doubts about the confidence there can be about the continuing high levels of institutional control necessary for storage to be credible. If the case for having sufficient confidence in the long-term safety of geological disposal is accepted, much further research is needed. An example derives from regulatory views of the Nirex concept of phased geological disposal for ILW, the most highly developed UK geological disposal concept to date. The Environment Agency, replying to Nirex's report on the viability of its concept believes that a safety case can be made, but that the present state of development of the concept leaves many key technical challenges to be overcome.[7]

Conclusion

33. The main arguments that CoRWM heard for and against confidence in geological disposal have been set out together with arguments for and against long-term storage. All were influential in the process by which CoRWM members made decisions on the potential role of geological disposal in its overall recommendations. There is a spectrum of individual views among CoRWM members on the degree of confidence they have in the long-term safety of geological disposal. However, the conclusion from the above arguments considering all knowledge streams together was, for the great majority of members, that they had sufficient confidence to consider geological disposal for recommendation to Government as an end-point, given the current state of knowledge.

34. However the final decision on whether or not to recommend geological disposal as an end-point for radioactive waste management depended on a comparison between the merits of geological disposal and of long-term interim storage, given that confidence in geological disposal, especially its safety characteristics, can never be absolute. The flexibility argument for continuing storage is attractive and there are ethical arguments in its favour as well. But the critical issue for most members of CoRWM, given their confidence that geological disposal would not constitute a significant burden on future generations, was that the safety of long-term interim storage depends on an expectation of continuing institutional control over several hundred years. The risk of loss of institutional control while waste is still in storage is that there may be potentially large safety and environmental consequences in the relatively near future. For the great majority of CoRWM members this was influential in judging the desirability of moving towards geological disposal as quickly as practicable while ensuring that a robust programme of storage is achieved until a repository is available. All CoRWM members were prepared to endorse the wider package of recommendations presented in Chapter 14.

References

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3 UK Nirex Ltd, 'The viability of a phased geological concept for the long-term management of the UK's radioactive waste', Nirex Report N/122, November 2005.

4 UK Nirex Ltd and British Geological Survey, "A note by the British Geological Survey and Nirex on the Suitability of UK Geology for Siting a Repository for Radioactive Waste", document 1797, March 2006.

5 UK Nirex Ltd, 'Biological uptake routes for worst case probabilistic realisations in the assessment of the groundwater pathway for the Nirex PGRC', Nirex Technical Note 509002, July 2006.

6 Committee on Radioactive Waste Management, 'CoRWM's work and the views of the Low Level Radiation Campaign', document 1633, July 2006.

7 Environment Agency/Nuclear Waste Assessment Team, "Review of Nirex Report: 'The Viability of a Phased Geological Repository concept for the Long-Term management of the UK's Radioactive Waste", reference NWAT/Nirex/05/003, November 2005.

Chapter 14 CoRWM's recommendations

CoRWM is presenting an integrated set of recommendations, covering three interdependent strands. It recommends geological disposal as the end point for the long-term management of radioactive wastes and robust storage in the interim period, including provision of contingency against delay or failure in reaching the end point. The third strand focuses on implementation, including the need for a staged process, flexibility in decision making and partnership with communities willing to participate in the siting process.

1. The following are CoRWM's final recommendations. Our judgements are based on what we learned from a combination of scientific advice, overseas experience, public and stakeholder engagement (PSE), and consideration of ethical issues. Through its engagement with the public and stakeholders, CoRWM believes that its recommendations provide the basis for inspiring confidence. We commend them to Government as an integrated package and urge progress without delay so that the momentum established by the CoRWM process is not lost. CoRWM considers that continued openness and transparency is essential for the successful implementation of these recommendations.

Recommendation 1: Within the present state of knowledge, CoRWM considers geological disposal to be the best available approach for the long-term management of all the material categorised as waste in the CoRWM inventory when compared with the risks associated with other methods of management. The aim should be to progress to disposal as soon as practicable, consistent with developing and maintaining public and stakeholder confidence.

2. A large majority of CoRWM members have sufficient confidence in the long-term safety of geological disposal, and its ability to reduce the burden on future generations, to recommend it as the preferred end-point. This view took into account various factors, including specialist judgements during Multi-Criteria Decision Analysis (MCDA), the strong consensus that exists in the earth sciences community, and estimates of public exposure to radiation in the far future after repository closure. Most members considered that the risks from geological disposal were substantially smaller than those from long-term storage, which they considered to be vulnerable to terrorist actions, war, loss of institutional control, and severe environmental change. It was stressed, however, that absolute confidence in the long-term safety of geological disposal could not be assumed. One member challenged whether a judgement of sufficient confidence could be reached in the light of the uncertainties associated with repository performance and argued that the risks associated with storage could be mitigated in part by the type of storage regime adopted (siting away from the coast, underground, etc.).

Recommendation 2: A robust programme of interim storage must play an integral part in the long-term management strategy. The uncertainties surrounding the implementation of geological disposal, including social and ethical concerns, lead CoRWM to recommend a continued commitment to the safe and secure management of wastes that is robust against the risk of delay or failure in the repository programme. Due regard should be paid to:

i. reviewing and ensuring security, particularly against terrorist attacks
ii. ensuring the longevity of the stores themselves
iii. prompt immobilisation of waste leading to passively safe waste forms
iv. minimising the need for repackaging of the wastes
v. the implications for transport of wastes.

3. CoRWM recognises that there are social and ethical concerns that might mean there is not sufficient agreement to implement geological disposal at the present time. In any event, the process of implementation will take several decades. This period could last for as long as one or two generations if there are technical difficulties in siting or if community concerns make it difficult, or even impossible, to make progress at a suitable site.

4. The existing wastes in the CoRWM inventory are in storage on nuclear sites and future wastes, as they arise, will also be placed in storage. CoRWM recognises the work that the Nuclear Decommissioning Authority (NDA) and others are carrying out in relation to storage of radioactive waste on those sites for which they have responsibility. Over the timescale for implementing geological disposal, some of the UK's present stores may need to be refurbished or replaced and new stores for future wastes will be required. CoRWM's view is that arrangements are needed – as part of an overall strategy – to take account of the possibility that a repository may be delayed or may never be constructed and that there will be a need to keep the wastes secure and safe for longer than previously thought. The Government will need to take account of the specific issues raised by this requirement for interim storage:

   i. The design and engineering of new stores, and the refurbishment of existing ones, will need to take account of risks to the security of their contents, now and into the future. This includes, but is not limited to, the vulnerability of the waste form and the degree of protection provided against attack, including the possibility of putting stores underground or providing them with heavily reinforced walls and roofs.

   ii. The design lifetimes of new stores should cover a period of interim storage of at least 100 years to cover uncertainties associated with the implementation of a geological repository. The replacement of stores should be avoided if at all possible.

   iii. Regulators agree that wastes should be made passively safe as soon as practicable.

   iv. The repackaging of wastes is regarded by the regulators as inherently undesirable, mainly because of the risk of exposure of workers to radiation. They have also expressed concern about the ability of packages to contain intermediate level waste (ILW) much beyond 100 years.

   v. The transport of wastes is an important issue. In particular, the 'double movement' of waste should be avoided as far as possible, e.g., building interim stores at regional or central sites only to have to move the wastes for a second time in the event that disposal facilities are implemented elsewhere.

Recommendation 3: CoRWM recommends a flexible and staged decision-making process to implement the overall strategy, which includes a set of decision points providing for a review of progress, with an opportunity for re-evaluation before proceeding to the next stage.

5. Experience in the UK and overseas shows that implementation should be a staged process of sequential decision making, with the main elements and stages agreed as milestones by outcome, before the process starts, with clear and transparent roles for the participants. The process should be flexible and include the evaluation of ongoing research and development (R&D) and a review of progress, at pre-determined points, to establish whether there is sufficient agreement to move to the next phase and to decide whether to adopt any proposed alternatives.

Recommendation 4: There should be a commitment to an intensified programme of research and development into the long-term safety of geological disposal aimed at reducing uncertainties at generic and site-specific levels, as well as into improved means for storing wastes in the longer term.

6. CoRWM has made its recommendations on the basis of the best available scientific and societal information. It recognises that there is a need for further research into the characteristics of geological disposal in the UK and that this should address and seek to reduce the uncertainties surrounding long-term safety. More research is required into improving the robustness of storage.

Recommendation 5: The commitment to ensuring flexibility in decision making should leave open the possibility that other long-term management options (for example, borehole disposal) could emerge as practical alternatives. Developments in alternative management options should be actively pursued through monitoring of and/or participation in national or international R&D programmes.

7. CoRWM recognises that there are rapid developments in science and technology so practicable alternatives may become available in the period up to the closure of a repository. CoRWM therefore recommends a flexible approach; it would be wrong to deny future generations the opportunity to avail themselves of alternative methods because of too rigid a focus on the end-point of geological disposal. An example is boreholes where there could be benefits from the enhanced isolation and security offered for some wastes, but there is not sufficient knowledge to put the option forward at this stage. CoRWM is therefore recommending that appropriate research and development should be undertaken into alternative management options.

Recommendation 6: **At the time of inviting host communities to participate in the implementation process, the inventory of material destined for disposal must be clearly defined. Any substantive increase to this inventory (for example creation of waste from a new programme of nuclear power stations, or receipt of waste from overseas) would require an additional step in the negotiation process with host communities to allow them to take a decision to accept or reject any additional waste.**

8. Potential host communities will need to know the nature and the quantities of the waste before they consider possible participation in implementation. This was one of the key responses from PSE, both from the public and NGO stakeholders. If no decision has been taken about existing uranium, spent fuel and plutonium stocks by that time, or if additional materials or wastes are created for example, from nuclear new build, CoRWM is clear that these must be subject to a separate process.

Recommendation 7: **If a decision is taken to manage any uranium, spent nuclear fuel and plutonium as wastes, they should be immobilised for secure storage followed by geological disposal.**

9. In deriving its recommendations, CoRWM has assumed that all of the UK's un-reprocessed spent fuel, all the uranium and plutonium from reprocessing are managed as waste. Should they be declared as waste, they would have to be packaged and then stored, probably for several decades, before disposal.

Recommendation 8: **In determining what reactor decommissioning wastes should be consigned for geological disposal, due regard should be paid to considering other available and publicly acceptable management options, including those that may arise from the low level waste review.**

10. CoRWM makes a caveat regarding reactor decommissioning waste (RDW) some of which is likely to be short-lived ILW. CoRWM was not required to make recommendations about siting of facilities but notes that, if the option of disposing of low level waste (LLW) on site is publicly acceptable and is pursued, consideration should be given as to whether a safety case could be made for including appropriate RDW in order to avoid transport.

Recommendation 9: **There should be continuing public and stakeholder engagement, which will be essential to build trust and confidence in the proposed long-term management approach, including siting of facilities.**

11. CoRWM's experience highlights the importance of continuing to build trust and confidence through effective forms of public and stakeholder engagement.

Recommendation 10: **Community involvement in any proposals for the siting of long-term radioactive waste facilities should be based on the principle of volunteerism, that is, an expressed willingness to participate.**

12. Experience in the UK and abroad clearly demonstrates the failures of earlier 'top down' mechanisms (often referred to as 'Decide-Announce-Defend) to implement long-term waste management facilities. It is generally considered that a voluntary process is essential to ensure equity, efficiency and the likelihood of successfully completing the process. There is a growing recognition that it is not ethically acceptable for a society to impose a radioactive waste facility on an unwilling community.

Recommendation 11: Willingness to participate should be supported by the provision of community packages that are designed both to facilitate participation in the short term and to ensure that a radioactive waste facility is acceptable to the host community in the long term. Participation should be based on the expectation that the well-being of the community will be enhanced.

13. In the light of overseas experience CoRWM has concluded that communities are unlikely to come forward or agree to engage unless a comprehensive Involvement Package will be provided, which will, in turn, allow the negotiation of a Community Package. The scale and scope of the funding will need to be determined nationally and agreed beforehand in discussion with relevant parties. For the process to be fair, a local community hosting a facility should be better off after siting than before. This reflects and acknowledges the service that is being provided for society at large.

Recommendation 12: Community involvement should be achieved through the development of a partnership approach, based on an open and equal relationship between potential host communities and those responsible for implementation.

14. Some of the most promising programmes overseas are based on the potential host community working in partnership with an implementing body to achieve a successful outcome for both. One of the advantages of the partnership approach is that it achieves an environment in which host communities can engage with an implementing body without feeling victimised by a national process over which they ultimately have little control.

Recommendation 13: Communities should have the right to withdraw from this process up to a pre-defined point.

15. In processes that are successfully moving forward abroad, the right of the potential host community to withdraw from the process is an important factor in determining the willingness of communities to participate. This right has some limitations. There will come a point when the process of implementation has proceeded so far that withdrawal would not be possible.

Recommendation 14: In order to ensure the legitimacy of the process, key decisions should be ratified by the appropriate democratically elected body/bodies.

16. Democratic representation and ratification of decisions is necessary to achieve overall acceptability and legitimacy for decisions. What decisions require democratic endorsement, and at what level they should be taken, is a matter for further work.

Recommendation 15: An independent body should be appointed to oversee the implementation process without delay.

17. Given the long history of delay and deferment in the UK on the issue of radioactive waste management, it is clear that any new or revised institutional arrangements for progressing the radioactive waste management process in the future need to draw on the current goodwill and momentum achieved by the CoRWM process. There is a pressing need to establish an appropriate institutional basis to carry the process forward. CoRWM's view is that the staged decision-making process should be supervised by an independent body with overall responsibility for overseeing the research and development programme, the siting strategy and ensuring proper engagement with the public and stakeholders at each stage. Government should set up such a body without delay.

18. There should also be an implementing body responsible for the construction and operation of any necessary facilities, and related research and development. The roles of the overseeing body and the implementing body at each stage of the decision-making process must be clearly defined in advance. It is clear from previous UK experience and recent experience in Sweden and Finland, that the regulators have an important role in the successful implementation of the process.

CoRWM takes no position on the desirability or otherwise of nuclear new build. We believe that future decisions on new build should be subject to their own assessment process, including consideration of waste. The public assessment process that should apply to any future new build proposals should build on the CoRWM process, and will need to consider a range of issues including the social, political and ethical issues of a deliberate decision to create new nuclear wastes.

Chapter 15 Geological disposal

This chapter describes different forms and characteristics of geological repositories - about which many views have been expressed during public and stakeholder engagement. CoRWM's advice is intended to help people appreciate the implications of its recommendation for disposal.

1. CoRWM is recommending geological disposal as the end point in the long term management of radioactive waste. The Committee was not asked by Government to review or suggest specific designs for facilities. That will be the responsibility of the implementing body (see Chapter 17). Nevertheless, CoRWM has considered some of the fundamental differences in repository design concepts including their applicability to different waste streams and the extent to which they incorporate a degree of flexibility for management in the future. An explanation of CoRWM's rationale for its recommendations on geological disposal is provided in Chapter 13 and further elaboration on the uncertainties raised is given in Chapter 18.

Repository design concepts

2. Geological disposal in an underground repository is the waste management option that is currently favoured by many countries for spent fuel and HLW. These countries include Belgium, France, Finland, Germany, Japan, Sweden, Switzerland and the United States. No country is yet operating a geological repository for these materials but some, e.g. Finland and the US, have identified sites. Construction of the geological repository for spent fuel at Olkiluoto, Finland, has started and the repository is scheduled to become operational within the next 10 - 15 years.

3. Some countries, e.g. Switzerland and Germany, are also considering geological disposal for the management of long-lived intermediate level waste. The US is operating a geological repository, (WIPP in New Mexico) for the disposal of long-lived intermediate level waste from defence-related activities and Germany has recently licensed the Konrad mine facility, but no other country has yet commissioned a geological repository for intermediate level waste. Sweden and Finland have operated shallow facilities for short-lived operational intermediate and low level wastes for some time but these are not geological repositories and are better described as shallow vaults.

4. Geological disposal is based on the concept of the retention of the waste by a combination of engineered containment within a geological barrier. This provides a series of multiple engineered barriers comprising the solid conditioned waste-form, the waste container and any waste overpack (collectively referred to as the waste package), a buffer made of a material such as clay, grout or crushed rock that separates the waste package from the host rock together with any tunnel linings and supports. The geological barrier supports the engineered system and provides stability over the long term during which time radioactive decay reduces the levels of radioactivity. The geological barrier provides a stable environment over the long term and reduces the return to the biosphere of any radioactivity released from the engineered barriers.

5. CoRWM's list of options referred to deep geological disposal. The word 'deep' was used to distinguish this option from shallow burial. However, some PSE responses pointed out that the term 'deep geological disposal' was misleading; depth is not a key factor, it is the geology and hydrogeology that are of importance. Some repository concepts, such as that proposed for Yucca Mountain, are not deep below the surface. CoRWM therefore decided to refer to this option as 'geological disposal'. The actual depth of a geological repository will depend on a variety of factors, including the rock type (its strength and stability), and the local geological and hydrogeological conditions, but excavation would typically be to a depth of between 200 – 1000 metres. Geological repositories may be

constructed in a variety of rock types including crystalline rocks, clays and salt. Unlike some countries, such as Canada and Scandinavia, where there is a uniform underlying geology, the UK is underlain by a variety of different rock types. The British Geological Survey estimates that approximately 30% of the land surface may lie above geologically suitable rock formations.[1]

6. Concepts for geological disposal are based on an extremely long period of containment of the waste during which time its level of radioactivity will diminish through the process of decay. When, at some time far into the future, the engineered barriers fail and some radioactivity is slowly released into the surrounding rocks and groundwater and, ultimately, into the biosphere, the level of radioactivity is expected to be insignificant in terms of impacts on human health and the environment. It is apparent from PSE responses that some people are sceptical of this concept, pointing out that, regardless of other uncertainties associated with disposal, the engineered barriers could fail relatively quickly. Some even question whether this is really a ‘disposal’ concept because radioactivity ultimately comes back into the biosphere, albeit in a diminished form. Even those people who were broadly in favour of geological disposal often expressed reservations. One of the key messages coming from CoRWM’s public and stakeholder engagement was the desire to balance the wish to dispose of the waste once and for all with the wish to allow for the possibility of getting the waste out again if this was considered necessary at some time in the future. This idea of disposal coupled with an element of retrievability has been adopted in most other national programmes in response to public concerns over the ‘finality’ of disposal. Many of the designs being developed in other countries incorporate some flexibility, both in the timing of closure and in the ability to remove waste once it has been emplaced, in order to address these concerns.

Retrievability and monitoring

7. CoRWM’s short-list included three disposal options: geological disposal, phased geological disposal and boreholes. The Nirex phased geological disposal concept for ILW, which was the basis of CoRWM’s phased geological disposal option, is one such design concept. It involves the incorporation of design features that would enable a repository to stay open and function as a storage facility for several hundred years – though it could be sealed much sooner, even vault by vault as each is filled. By contrast, CoRWM’s geological disposal option is based on a direct disposal concept. It involves an intent to backfill and seal as soon as waste is emplaced, although the means of closure could vary from sealing each disposal vault once full, to sealing the entire repository once all the waste is emplaced. The geological requirements are broadly the same for both geological disposal and phased geological disposal[1] although the need to maintain large open vaults as a store in the phased geological disposal concept might preclude some particular geologies. There would also be some differences in the engineered components, relating to the need to provide for on-going maintenance and refurbishment while the facility operated as a store. However, these differences in design are regarded by many experts as matters of detail along a design continuum going from immediate disposal at one extreme to an integrated pre-determined programme of storage followed by disposal at the other. All of the design concepts incorporate some level of retrievability, in the broadest sense of the word.

8. CoRWM devoted considerable time to a discussion of retrievability in order to identify the possible reasons why waste might need to be retrieved, or ought not be retrieved, and to assess the extent to which options, in practice, allowed retrievability. The term ‘retrievability’ is used as a short-hand for a number of different ways of getting the waste out. At its simplest, the waste could be removed by reversing the original emplacement process. This form of retrievability, which CoRWM describes as reversibility, could be provided by storage facilities, for example. Under some repository design concepts, it would be possible to withdraw the waste by building in a methodology that would allow access to the waste even after vaults had been backfilled; for example by keeping access tunnels open for a period after emplacement and ensuring that the backfill could be removed. CoRWM describes this as retrievability. In addition to the ‘built-in retrievability’

offered by these methods of removing the waste, CoRWM identified a third category, recoverability in which waste is recovered from a repository by mining or similar intrusive methods. Recoverability is not part of the design specification and would be likely to pose greater technical challenges and be more expensive.

9. CoRWM found it useful to consider concepts for geological disposal from the viewpoint of the extent to which they allow for the removal of the waste. These are described as they might be applied to ILW, but similar approaches could be developed for HLW and spent fuel. This approach categorised geological disposal in terms of four broad approaches to backfilling and sealing a geological repository:

   i. The vaults are each backfilled with grout (cement) as soon as they are full of waste. In practice, they would be backfilled in batches in order to keep the grouting process separated from the emplacement of waste in empty vaults. This approach creates a good chemical environment around the waste packages at the earliest opportunity and thus preserves the integrity of the stainless steel containers to the greatest possible extent. The removal of the grout by water jetting has been demonstrated. Thus, the waste is retrievable, in principle, until the repository as a whole is backfilled and sealed.

   ii. The first vault is backfilled when it is full of waste and the integrity of the waste packages is monitored. Backfilling of the remaining vaults is delayed until a point is reached when there is sufficient confidence to backfill the remaining vaults. This enables the monitoring of the first vault to be undertaken under conditions that represent those that will occur when all the vaults have been backfilled. Apart from the first vault, this approach provides reversibility.

   iii. None of the vaults are backfilled until all the waste is emplaced, when the whole repository is backfilled and sealed. This approach provides reversibility up until this point. In the meantime, the waste is monitored in the same way as it would be in a store.

   iv. After the waste is emplaced, the facility could function as a store and all backfilling could be delayed for up to a few hundred years (although backfilling could be carried out sooner if so desired). Nirex's phased disposal concept is an example of this approach.*

10. Clearly, then, a repository designed for phased geological disposal could also be operated so that it could deliver the other three geological disposal approaches. The main difference lies in the intention at the design phase. Phased geological disposal is intended to allow for a period of interim storage underground followed by disposal. The other approaches are intended to deliver disposal but incorporate a degree of flexibility that will permit retrievability.

11. Approach (iv) (phased geological disposal) requires the vault to remain open for a period of up to a few hundred years. Because of the need for geological stability during this period, the geological criteria may be more stringent for approach (iv) than for the others. It also requires the atmospheric conditions in the repository to be carefully controlled to preserve the integrity of the waste packages for as long as possible and minimise the extent of repackaging. Approach (i) (early closure) requires the shortest period of maintenance of the open vaults. Approaches (ii)

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* In a recent report [4], Nirex states that "…some generic and much more site specific research is still needed before a phased geological repository can be implemented." In addition, the Environment Agency (EA), in critiquing [5] the Nirex 'Viability Report' for its phased disposal concept, said "We are concerned that plans for long periods of storage (in the phased deep geological option)…are not sufficiently underpinned technically." And that "…Nirex present an overly optimistic view…" The EA also listed a number of key technical challenges that it considers remain in developing the concept.

and (iii) lie between these two extremes but could require the vaults to be stable for the 65 years that Nirex estimate that it would take to emplace the UK's inventory of intermediate level waste[2].

12. If the repository is designed for approach (iv), the decision on what approach is taken can be postponed until the first vault is full. As discussed below, this is regarded as an advantage by some and a disadvantage by others, because it implies that a decision as to whether to store the waste for a long, but interim, period can be delayed for future generations to decide. If approaches (ii), (iii) or (iv) are selected, the decision on when to backfill and seal can be made at any time up to the design life of the repository. However, a decision on closure will also need to take account of the design life of the containers. CoRWM's understanding is that containers will retain their integrity for a period of about 100-150 years but there is a need for greater clarity on this point.

International Experience

13. In other countries where geological disposal has been selected as the long term management option it has been also recognised that there is a need to provide a degree of retrievability in order to meet public concerns. The challenge is to find a way of doing this without jeopardising the fundamental safety concept.

14. The Swiss concept of Monitored Geological Disposal for spent nuclear fuel involves the construction of a pilot vault alongside the main repository vault. The intention is that conditions within the pilot vault will be monitored for a period of between 50-100 years. Meanwhile, waste emplacement in the main repository vaults will proceed and individual vaults will be backfilled. This would not, however, preclude the removal of the waste should this be deemed necessary.

15. In the Scandinavian KBS-3V concept for spent nuclear fuel, the emplacement tunnels and the gallery are backfilled with clay but the main access ways and the access tunnel need not be backfilled until the repository is full. In principle, these can be kept open for several hundred years - as long as the period of storage envisaged in the Nirex phased disposal concept. The removal of the clay has been demonstrated. Thus, this concept provides retrievability until the repository is closed. It would also provide protection against misappropriation of the fuel and plutonium.

16. In the Belgian concept for HLW, the canisters are within stainless steel tubes, which need not be backfilled for some time. The tubes can be withdrawn. Thus, this concept provides a type of retrievability. It also provides some protection against misappropriation.

17. The Japanese nuclear management body has developed a range of repository concepts for HLW disposal as a 'catalogue' from which the most appropriate might be selected for specific sites. The Cavern Retrievable (CARE) concept provides the maximum flexibility and ease of removal. In this concept the fuel is placed in a stable matrix in thick-walled steel casks, which are placed in vaults. Any of the four approaches outlined above can be implemented. This concept, therefore, could be used to provide either reversibility or retrievability. It provides less protection against misappropriation.

CoRWM's view

18. Many citizens and stakeholders support the concept of phased disposal. What they have said is broadly consistent with earlier messages throughout CoRWM's programme: people generally support a management strategy aimed at reducing burdens on future generations while at the same time presenting sufficient

flexibility to address concerns about public confidence and enable retrievability in response to possible future technological advance or new information about risks and opportunities.

19. Others see phased disposal as a false reassurance that increases environmental, security and safety risks. There are concerns that, if a repository was left open for a period of interim storage, there would be an increased risk of release of radioactivity to the environment. There are also concerns, because of the need to maintain the facility in its storage phase, about the time period for which institutional control will be needed and that this will increase the risk to humans, including the workers who will have to maintain it for longer until it is sealed and brought to a state of "passive safety". It might also increase the vulnerability of the waste to terrorist action.

20. CoRWM's view is that leaving a repository open, for centuries after waste has been emplaced, increases the risks disproportionately to any gains.

21. Even if a form of direct geological disposal is chosen, it will be a hundred years or so before the waste is completely sealed in place and reversal or retrievability is no longer possible. This time delay may provide sufficient reassurance for those people who wish to retain the possibility of doing something else with the waste, for example, utilise better methods of waste management which have been developed in the meanwhile or because a use has been found for the 'waste'.

22. For some people, a period of monitoring the conditions within a repository is regarded as important to check that the performance of the repository in practice accords with the models forming the basis of the safety case. The Nirex concept and the Swiss concept are two examples where there is a built in period of monitoring conditions in a repository before and after vaults are backfilled. However, the concepts only provide for monitoring over a few hundred years at most, and cannot provide reassurance about repository performance in the long term, which is usually the period of greater concern because of the uncertainties over what will happen when the engineered barriers fail. Monitoring at the surface will be possible for any design of repository and it will be possible to continue this for as long as there is institutional control.

23. These concerns over the performance of a repository are considered in Chapter 18 on uncertainties, as well as in Chapter 13 which considers challenges to the conventional views about repository safety in the long term.

Repository designs for different wastes

24. Technically, geological disposal, phased or otherwise, could be applied to all the wastes in the CoRWM inventory; although the high cost of excavating a repository at some depth underground means that the option is sometimes considered only for wastes with long half-lives that need to be isolated from the surface environment for very long periods of time - e.g. HLW, spent fuel, long-lived ILW, plutonium and uranium.

25. Geological repository designs for HLW and spent fuel differ from those for intermediate level waste in terms of the construction materials, the geometry of the engineered barriers, and the backfill used to contain the waste. However, it may be possible to co-locate a UK geological repository for HLW and spent fuel with one for intermediate level waste so that only one site needs to be selected. The disposal vaults for different wastes would have to be kept separate, for example because the high alkalinity conditions generated by any cementitious backfill within an intermediate level waste repository can be detrimental to the stability of the buffer in the HLW repository.

26. The common feature of geological repositories for HLW and spent fuel is a series of long horizontal disposal tunnels, a few metres in diameter, into which the waste packages are emplaced.[3] Various ideas have been considered for the emplacement of the waste packages in these tunnels. In some designs, packages would be emplaced lengthways along the tunnels whilst, in other designs, waste packages are emplaced in short deposition holes drilled either into the floor or sides of the tunnels.

27. In most designs, the waste package is made from carbon or stainless steel but, in Finland and Sweden, it is proposed to encapsulate spent fuel in cast-iron containers surrounded by a 5 cm thick copper shell (due to its very slow corrosion). In the United States, it is proposed to use steel containers with a nickel-alloy shell. In most designs, the buffer will be compressed bentonite clay because this has a very low permeability and therefore the passage of radionuclides through the clay will be dominated by diffusion rather than by transport in flowing groundwater.

28. The common feature of geological repositories for ILW is an array of large disposal vaults, usually tens of metres long and several metres wide and tall. Intermediate level waste is much more chemically and physically varied than HLW, so there are many different waste package designs to allow for different waste characteristics. In most designs, intermediate level waste produced by reactor and fuel reprocessing operations is typically immobilised in individual drums or containers by mixing it with cement or bitumen. These drums and containers may then be grouted into larger boxes to form a discrete waste package. Larger intermediate level waste components from decommissioning may be grouted directly into larger waste packages. The waste packages are designed to be stacked in the disposal vaults. The void spaces between packages, and between packages and the host rock, are backfilled with a concrete or cementitious grout or clay buffer. In contrast, the WIPP repository for ILW in the United States is excavated in salt rock formations and uses crushed salt and bags of magnesium oxide for a backfill. Because ILW is chemically less stable, package integrity poses more of a problem than for HLW, especially where the repository design concept involves an extended delay of backfilling after emplacement of the packages.

29. CoRWM does not commend one design over another. Before decisions on this are made, it is necessary to identify sites that are suitable for a repository and whose communities are willing for detailed investigation to take place. Those investigations, together with other research and Government decisions e.g. on what materials to declare as wastes, will help to identify what specific designs are most suitable. The general approach to site selection is not to seek the best possible site from a geological point of view, because other criteria will also be important; but rather to identify a site that meets the necessary geological and other criteria and to engineer the design to the locality. Detailed decisions on repository design should not be made until potential host communities have been identified. Once this has been done, the repository can be designed with the local geology in mind and taking account of the wishes of the community.

Conclusion

30. Elsewhere in this report, CoRWM recommends that Ministers start the process of implementing geological disposal as soon as practicable. However, it is unlikely that underground investigations will start for at least 15-20 years, and a decision on the detailed repository design will not be needed until then. There are already several different repository concepts designed to allow for monitoring and possible retrieval before final closure and it is likely that thinking in this area will develop further. The delay before site investigations begin will allow time for further

research, discussion and agreement with potential host communities and others on the design features that should be included.

References

1 UK Nirex Ltd and British Geological Survey, "A note by the British Geological Survey and Nirex on the Suitability of UK Geology for Siting a Repository for Radioactive Waste", document 1797, March 2006.

2 CoRWM, “Timelines for Implementation”, document 1779, June 2006.

3 Enviros, "Summary descriptions of CoRWM's short-listed options", document 1420, November 2005.

4 UK Nirex Ltd, “Potential Areas of Future Geosphere Research”, Nirex document 494794, February 2006.

5 Environment Agency/Nuclear Waste Assessment Team, “Review of Nirex Report: ‘The Viability of a Phased Geological Repository concept for the Long-Term management of the UK’s Radioactive Waste”, reference NWAT/Nirex/05/003, November 2005.

Chapter 16 Interim storage

This chapter sets out CoRWM's views on the issues to take into account in reaching decisions about the arrangements that should be put in place to store radioactive waste until a repository is ready - about which many views have been expressed during public and stakeholder engagement.

1. In Chapter 14, CoRWM has recommended that, given the present state of knowledge, geological disposal of all the higher activity radioactive waste in the CoRWM inventory should be implemented as soon as practicable on a timescale that is consistent with developing and maintaining public and stakeholder confidence. However, CoRWM recognises that storage is central to its recommended strategy. This is because it will, in any case, be several decades before a repository or repositories can start to accept the waste and, until the necessary social, political and scientific requirements have been met, the implementation of a repository is not certain.

2. Adequate requirements for storage are, therefore, integral to the implementation of the recommendations. The process that CoRWM recommends for implementing a repository includes both engagement with the public and stakeholders at a national level during its earlier stages and the development of Community Packages at a local level within Partnerships. The latter will require deliberation and it is very important for the success of the implementation process that the longevity of storage gives sufficient time for this deliberation to be conclusive.

3. The Nuclear Decommissioning Authority (NDA) is managing the decommissioning and clean up of civil public sector nuclear sites including the treatment, packaging and storage of the radioactive waste that is produced. The NDA has published its strategy for carrying out this task[1], which includes the evaluation of options for siting ILW stores and the criteria that will be used in evaluating these options. The type and longevity of stores that will be required, given the range of materials and wastes for which the NDA is responsible, have to be factored into the strategy. Particular issues for storage are posed by plutonium, uranium and spent nuclear fuel that may, or may not, come to be managed as wastes in the future. Other producers, such as the Ministry of Defence and non-nuclear industries, have similar responsibilities for the radioactive waste and material that they produce.

Storage options

4. CoRWM's assessment of the options for the long-term management of radioactive waste included six storage options. Although the assessment was of long-term management options, information and comments obtained during the assessment of storage options are also applicable to a consideration of the role of storage as part of an overall waste management strategy. Many participants in CoRWM's PSE programme expressed the view that the Committee should report what it learned about the type and location of facilities that could be used for interim storage and that, as far as possible, it should set out its views on a storage regime that meets the requirements of the recommendations. Because some decisions on storage will be needed in the near future, CoRWM believes it is helpful to set out its thinking in some detail.

5. CoRWM short-listed the following six storage options[2]:

   i. stores with the current levels of protection against terrorist attack at or close to the sites where the waste is produced;

ii. stores with the current levels of protection against terrorist attack at a central location;

iii. surface stores with an enhanced level of protection against terrorist attack at or close to the sites where the waste is produced;

iv. surface stores with an enhanced level of protection against terrorist attack at a central location;

v. underground stores with an enhanced level of protection against terrorist attack at or close to the sites where the waste is produced;

vi. underground stores with an enhanced level of protection against terrorist attack at a central location.

Key issues in public and stakeholder input

6. Attention to what the public and stakeholders told CoRWM about storage was built into the evaluation of options at an early stage. Discussion of different types of stores featured, for example, in the first stage of PSE in which the merits and disadvantages of surface and underground stores were discussed[3]. Following CoRWM's decision to short-list the generic long-term interim storage option and some initial thinking of the kind of storage that would be needed[4], the public and stakeholders responded in more detail, adding further comments, for example, on the number and locations of the stores that might be required, the transport implications of centralised stores, and the vulnerability of some store designs to terrorism[5].

7. In the options assessment of short-listed storage options, all six were assessed in detail on the basis that, with necessary regard to care and maintenance of the structures, they could offer a stand-alone form of management for at least 300 years. The period of interim storage as one part, albeit an essential one, of the recommended strategy is envisaged to be much shorter (see discussion of timescales below) which means that some of the conclusions of the assessment exercise may not be applicable. Nevertheless, the assessment provides valuable information on the performance of storage options and, with this caveat in mind, it can be used to inform decisions on interim storage in the context of the strategy.

8. Throughout CoRWM's PSE process, participants identified safety, security and the environment as issues of major importance. Specific environmental impacts and loss of amenity can only be assessed for specific sites but security emerged as an important generic discriminator between the storage options in the MCDA process. Unsurprisingly, the organisations that, as waste owners, would bear the financial burden of storage, judged cost to be important, but cost was of lesser importance to other stakeholders and to the public. Lastly, the longevity of stores was identified as a central consideration to both the implementation process itself and as a contingency in the event of failure or delay in securing a repository site or sites.

9. A number of issues have emerged that, in CoRWM's view, inform the question of how waste should be stored. These are: the time period over which the stores will be needed; the type of store; the location of the stores; and the cost of stores. To some extent, these also provide a valuable means of discriminating between the six storage options.

The timeline for CoRWM's strategy

10. Annex 5 shows an indicative timeline for the implementation of CoRWM's strategy. The timescale for implementing disposal is a crucial factor in determining how many stores will be needed, where they should be located, and how long they will need to remain operational. Based on experience overseas and interpreting it in a UK context, Nirex provided information to CoRWM for use in the expert workshops on the time that it would take to bring a repository in the UK into operation and the time that it would then take to emplace the volume of waste and materials in the CoRWM inventory.[6] These timescales were 33 years and 65 years respectively. In its review of the material presented to the workshops,[7] the Environment Agency pointed out that there are considerable uncertainties associated with these timescales.[8]

11. CoRWM believes that adequate time also needs to be built into the timeline for a site selection process based on the agreement of a willing host community, as discussed in Chapter 17 on implementation.

12. For indicative purposes, CoRWM suggests that storage could be needed, before a repository is available, for a period of 40 years from now (i.e., about 2046) and before completion of waste emplacement for 105 years from now (i.e., about 2110).[9]

The type of store

13. Issues relating to the type of store – i.e. whether it should be above or below ground and what level of protection it should have – relate mainly to the question of security and, in particular, vulnerability to terrorist attack. The security of nuclear sites is regulated by the Office of Civil Nuclear Security (OCNS), which is responsible for ensuring that the risks from terrorist and other threats are regularly reviewed and that the necessary protective measures are put in place. During the second phase of CoRWM's engagement process (PSE2), responses from a variety of sectors, including local government and NGOs, argued in favour of stores which protect against the type of terrorist attack which took place on the World Trade Centre in New York in 2001. Enhanced protection can be provided by constructing surface stores with a thick reinforced concrete cover, or ground cover can be used to provide the protection. The Swedish national interim store for spent nuclear fuel (CLAB), which is located 30 metres below the ground, provides an example of the latter. An aversion to placing waste underground was expressed by some stakeholders early in CoRWM's process. For example, at CoRWM's meeting with NGOs in Manchester in November 2004, above ground storage was supported on the basis of concerns that underground stores could become defacto disposal facilities whereas above ground storage provides an incentive for the active monitoring of wastes and management of stores.

14. In the MCDA process, security specialists from the UK and overseas assessed the six storage options against the criterion of vulnerability to terrorist attack. As with most of the MCDA workshops, the specialists represented a range of affiliations from the national regulators, NGOs and independent security specialists. The specialists agreed the following statement:[10]

> "The security specialists appointed to the CoRWM Specialist Security Workshop recognise that CoRWM is not responsible for the priority that is being given to the conditioning and mode of storage of nuclear waste forms prior to their transportation to the selected storage/disposal facility that may not occur for some decades into the future. However, it is our unanimous opinion that greater attention should be given to the current management of radioactive

waste held in the UK, in the context of its vulnerability to potential terrorist attacks.

We are not aware of any UK Government programme that is addressing this issue with adequate detail or priority, and consider it unacceptable for some vulnerable waste forms, such as spent fuel, to remain in their current condition and mode of storage. We urge the Government to take the required action and to instruct the NDA, in co-operation with the regulators, to produce an implementation plan for categorising and reducing the vulnerability of the UK's inventory of radioactive waste to potential acts of terrorism, through conditioning and placement in storage options with an engineered capability specifically designed to resist a major terrorist attack."

15. For long-term storage, the security specialists expressed a preference for stores with an enhanced level of protection. They identified the difficulty of predicting terrorist capabilities in the future and considered that an underground facility would provide the greater security. It would also be likely to provide protection against a greater range of potential attacks. While these views were provided specifically in the context of storage for 300 years, they may also be relevant in the shorter term.

16. A spectrum of public and stakeholder views emerged from engagement on these issues. The majority supported enhancing security to the maximum extent practicable, but some maintained a preference not to store waste underground (see, for example,[11]).

17. The safety specialists scored underground storage lower for safety than above ground because the former relies on active pumping to prevent groundwater ingress, which would fail in the event of loss of institutional control. This was an important consideration when evaluating storage for 300 years, but is less relevant for shorter-term interim storage.

The location of stores

18. CoRWM's assessment of short-listed options made a distinction between local stores, constructed on or near to existing nuclear sites, and centralised stores where wastes from more than one site would be brought together. The main issues raised here were the safety, security and environmental implications of transport of waste and the intra-generational issues raised by moving waste to a new locality.

19. Most of those participants in CoRWM's PSE process who commented on the transport issue argued that the transport of radioactive materials should be minimised or avoided altogether[11]. The key concern appeared to be the vulnerability of waste transport to terrorism, together with concerns about safety, the environment, and the impact on particular communities of moving the waste from one site to another. For the most part, respondents argued against the movement of any wastes, but some respondents thought that the transport of some materials, such as spent nuclear fuel, to improved interim storage facilities was justified even if the transport of large quantities of relatively low hazard waste (such as decommissioning arisings) was not. Some respondents expressed the view that there is a danger in over emphasising the problems associated with transport.

20. CoRWM did not explore in depth the issues surrounding storage with local stakeholders at the reactor sites. Issues such as the disadvantages of transport, local aspirations to return the sites to their original condition, and willingness to

accept waste from other sites require additional exploration with local stakeholders and should form part of NDA discussions for local sites. They are, nonetheless, touched on in the later sections of this chapter which make some observations on the issues associated with deciding where waste should be stored.

Safety issues

21. The safety specialists assessed the implications of transporting all the waste in the CoRWM inventory to a centralised location in terms of the risk from radiation, including accidents, and the non-radiation risk due to accidents. Studies show that the probability of a theoretical death being caused by radiation during transport is four times less than the probability of a death due to transport itself[12]. The specialists concluded that transport issues were much less important than the ability of the options to withstand events such as the loss of institutional control[13]. The environmental specialists drew similar conclusions.

Security issues

22. Many of the security specialists considered that there is a significant vulnerability to terrorist attack and misappropriation during transport. The type of material being moved influences the desirability or otherwise of transporting it. Highly radioactive material, such as spent nuclear fuel and HLW, is regarded by some members of the public and stakeholders as an attractive target for terrorists, although the robustness of the transport packages, the form in which the waste exists, the dispersability of the radioactivity, the utility of the waste to terrorists, and the level of security arrangements, are all elements for assessment in respect of the potential dangers represented by transport. Less radioactive material may pose a lower health risk but is generally far larger in volume and would therefore involve higher levels of transport.

23. When assessing the options in terms of the vulnerability to attack during transport, the security specialists did not distinguish between the waste streams. Although they did make this distinction when they assessed the options in terms of vulnerability after emplacement, they found little difference across the waste streams because, in their view, the political impact of any attack on a store, or during transport, regardless of the relative activity of, or hazard posed by, the material involved "would be huge even if there were not a significant dispersal of activity."[10]

24. However, when assessing the options in terms of misappropriation, the specialists judged that spent nuclear fuel, plutonium and highly enriched uranium would be much more attractive to terrorists than any of the other materials. In the MCDA, the local storage options with enhanced protection were judged to be the best performing storage options against the criteria as a whole for the higher activity wastes such as HLW, spent nuclear fuel, plutonium and ILW. This is because of the high weight given to security and the high importance that the security specialists gave to the transport risks associated with the central options.[14] No other criterion discriminated between the storage options to the same extent.

25. The evaluation of the actual terrorist risk associated with the movement of radioactive materials is complicated. While avoiding transport is a principle that is generally subscribed to, it is only one of the factors that need to be considered. It is also important to consider the potential impact on communities of retaining waste on existing sites.

Coastal erosion and sea level rise

26. The information that CoRWM collated on coastal erosion and sea level rise was summarised in a briefing report.[15] Most of the UK's existing nuclear sites are located on, or close to the coast. Early technical studies suggest that some of these sites are likely to be vulnerable to coastal erosion and inundation by sea water to a greater or lesser extent during the period between about 100 years and about 300 years from now. The vulnerability of existing sites that could be used for interim waste storage will need to be carefully assessed as part of the NDA's strategy.

Environment and loss of amenity

27. Several participants in CoRWM's process identified environmental impacts as additional reasons why transport should be minimised.[11] The site specific environmental and amenity issues could not be assessed in the absence of a specific site but will clearly be important considerations when the environmental impact of any new stores is being assessed.

Cost

28. As part of the MCDA process, CoRWM asked a group of specialists to provide a best estimate cost for each of the options over a 300 year period together with an estimate for the upper and lower bound. The uncertainties associated with the estimates are considerable and the value of cost as a discriminator between options was limited. It is clear, however, that a strategy based on local stores would be more expensive than one with centralised stores. It is more difficult to draw conclusions on the relative costs of strategies based on above ground and underground stores because the cost estimates used in the assessment included costs of refurbishment over the 300 years. Cost did not appear to be a major concern of many respondents in early PSE rounds.

The generic requirements for interim storage

29. In recommending a robust programme of interim storage (Recommendation 2, Chapter 14), CoRWM emphasises the need for a continued commitment to the safe and secure management of wastes that is robust against the risk of delay or failure in the repository programme. It states that due regard should be paid to:

   i reviewing and ensuring security, particularly against terrorist attacks;

   ii ensuring the longevity of the stores themselves;

   iii prompt immobilisation of waste leading to passively safe waste forms;

   iv minimising the need for re-packaging of the wastes; and

   v the implications for transport of wastes.

Reviewing and ensuring security, particularly against terrorist attacks

30. In the light of the comments made by the security specialists (see paragraph 14), CoRWM concludes that in reviewing existing stores, special attention should be given to their ability to withstand a terrorist attack and the need to reassure the public on this matter. This review should be periodically revisited during the storage period to ensure that the provisions remain adequate to meet terrorist threats.

31. New stores should be designed so that they can protect the waste from foreseeable terrorist attacks over the period of storage required.

Ensuring the longevity of the stores themselves

32. New stores should be designed in a way that will obviate, as far as possible, the need for major refurbishment or replacement in the period before the waste can be emplaced in the repository. This should take into account the uncertainties associated with the time that a successful repository programme will take.

33. The NDA has pointed out that the current design lifetimes of 50 to 100 years for stores are consistent with an anticipated date of 2040 for a repository being ready to accept first waste emplacements and it does not consider that there is any additional requirement to extend the design life of future stores.[16] The shorter design lifetime of 50 years leaves little margin for delay in repository construction, however, and the longer one of 100 years leaves little margin for delays in emplacement. Some stakeholders, such as Friends of the Earth Scotland, Greenpeace and the Nuclear Free Local Authorities, consider that the design lifetime should be 150 years.[16] CoRWM concludes that storage in one form or another will be required for at least a century and a further period should be allowed for contingencies.

Prompt immobilisation of waste leading to passively safe waste forms

34. Immobilising waste and putting it into passively safe waste forms will reduce the potential for accidents and the reliance on institutional control.

Minimising the need for re-packaging of the wastes

35. Extended lifetimes for stores of about 150 years would challenge the objective of emplacing the waste in a repository before repackaging becomes necessary unless the design of stores and packages, including the use of appropriate materials to ensure such longevity, were taken into account sufficiently early. Given the uncertainties on timing, R&D aimed at achieving store and package lifetimes that are robust to all the uncertainties, is recommended by CoRWM.

Implications for transport of wastes

36. The issues surrounding the transport of wastes need to be considered as part of the decisions on the location of waste stores. These decisions should be taken in the light of feedback from a programme of public and stakeholder engagement.

37. The planning for new interim stores should reflect the right balance between the desire to minimise waste transport and the potential benefits to be gained from moving waste from its existing location. This includes avoiding, where practicable and desirable, the double movement of the higher activity wastes from their current locations to a store at a new location and their subsequent movement to a repository. It also requires consideration of disposing of short-lived waste at its current locations subject to its acceptability to the local community.

Observations on managing waste streams

38. The requirements of an interim storage programme set out above are, CoRWM believes, well founded in the views of the members of the public and stakeholders with whom it engaged. The understanding gained needs to be translated as far as is possible into a discussion on the management of particular waste streams, including the location of facilities. CoRWM cannot make recommendations on site selection for long-term management but it would diminish the value of the

engagement and of this report if the logic of locating interim storage at some existing sites was to be absent from its advice.

39. ILW, LLW that cannot be disposed of at the LLWR and reactor decommissioning wastes are currently stored, and will continue to arise, at a number of nuclear sites around the UK. By contrast, HLW, spent nuclear fuel, plutonium and uranium are, or will be, stored at only a few sites; HLW, for example, exists only at Sellafield. It is for these, generally higher active, parts of the CoRWM inventory that the Committee considers it would be particularly helpful to add to the detail of its views on storage.

High level waste

40. All the HLW in CoRWM's inventory has been, or will be, produced at Sellafield. It is placed in the existing HLW store at Sellafield and, although this store may need refurbishment or replacement in the period before a repository for HLW is operational, there is no apparent reason for considering alternative storage in the short-term. The speed at which the liquid HLW is vitrified is subject to regulatory scrutiny and oversight but CoRWM recommends that this activity be given the highest priority. It is important that the security aspects of the HLW store at Sellafield are regularly reviewed and that the public are reassured of the continuing security against threats from terrorists.

41. It is CoRWM's view that HLW should remain at its present location unless climatic impacts make this impossible or the long term safety of the waste (in the event of a repository not being implementable) could be better secured by storage at another location. In the latter case, the possible benefits of any other storage site would need to be carefully balanced against the potential transport problems associated with its removal.

Spent nuclear fuel

42. The existing contractual arrangements between British Energy (BE) and British Nuclear Group (BNG) require BNG to manage existing stocks and future arisings of all Advanced Gas-cooled Reactor (AGR) spent nuclear fuel including the spent fuel that may arise from extending the lifetimes of any of the AGR stations. Under these arrangements, all the AGR fuel will be transported to Sellafield. Beyond a certain base quantity committed for reprocessing, the amount that will be reprocessed is at the discretion of BNG and the remainder will be stored until a decision is made on its future.

43. These arrangements do not apply to any of the spent fuel that is produced at the Sizewell B Pressurised Water Reactor (PWR) station. This PWR fuel is stored in the pond at Sizewell. The spent fuel storage pond was designed to accommodate 18 years of spent fuel arisings and will be reconfigured to accommodate approximately 30 years of spent fuel arisings, subject to obtaining the necessary consents. Additional capacity will be required to accommodate the fuel that will arise from the further ten years or so of the currently planned reactor lifetime. BE's current assumption, which is subject to further option assessment and approval by the regulators, is for the construction of a dry store on the site. This will accommodate all the spent fuel arisings from the station, including those in wet storage.

44. The recommendation to review the security aspects of storage is particularly pertinent to Spent Nuclear Fuel (SNF), which was specifically mentioned by the security specialists. In addition, some local stakeholders in the Sizewell area consider that the existing fuel represents a major hazard to the community.

45. SNF is currently not classified as a waste and is therefore not encapsulated in a form that is suitable for disposal. Thus, the timescale for disposing of SNF, if it were to be managed as a waste, may be longer than that for HLW because it would include the period needed to come to a decision and the time to design, construct and commission an encapsulation facility[17]. In any case, there will be a need to store the SNF at Sizewell for a period that is longer than the remaining operational lifetime of the 'B' station.

46. However, the stores for spent fuel would have to address the same security concerns as those for HLW and would require a design life that includes a contingency for delays in the programme for its encapsulation and disposal.

47. In addition, it is clear from the views of some stakeholders (see Chapter 17) that CoRWM's recommendations for community involvement as part of the implementation process should be applied in the case of new centralised stores at new locations. Chapter 17 also points out that the extent to which CoRWM's recommendations on implementation may be applicable to other new stores and to changes to existing stores is a matter for further consideration.

48. If the current plans to store AGR fuel at Sellafield and PWR fuel at Sizewell do not materialise, there will be a need for alternative storage. The desire to avoid the unnecessary transport of SNF raises the issue of whether a new store for SNF should be co-located with the repository, which would avoid the potential necessity to move the fuel twice, or whether the new store should be constructed before the repository site is identified - a scenario which would involve double movement. In view of the need to provide storage for spent fuel that is robust against terrorist attack for at least 40 years, the double movement of spent fuel may be justified, but this requires further discussion.

49. At Dounreay, the United Kingdom Atomic Energy Authority's (UKAEA's) strategy is to pack SNF in special containers and store it on site until a repository is available.

Plutonium

50. The UK's stockpile of plutonium is stored at Sellafield and future arisings from reprocessing will be stored at the same place. The NDA is evaluating the options for managing this stockpile, which include several options for burning it in reactors and several options for encapsulating it as waste.[18]

51. It is not for CoRWM to make a recommendation on whether or not the UK's stock of plutonium should be classified as a waste. However, in the light of feedback from the public and stakeholders, the Committee endorses the recommendations made by stakeholders to BNFL during its national dialogue to the effect that an alternative management approach to continued storage of plutonium in powdered form needs to be developed so that conversion to a passively safe form, suitable for long-term storage or disposal, is underway within 25 years and complete within around 50 years. If it is decided that the plutonium should be managed as a waste, it should be immobilised and stored at or close to its point of origin until it can be disposed of in a geological repository.

Uranium

52. Uranium is stored at a limited number of BNG and UKAEA sites and future arisings from reprocessing will occur at Sellafield. As with plutonium, the NDA is evaluating the options for managing the uranium stockpile, which include several options for burning some of it in reactors and several options for encapsulating it as waste.[18]

53. The vast majority of the UK's stockpile of uranium is in natural, low enriched or depleted forms and thus the potential risks associated with this material are considerably less than most of the other materials in CoRWM's inventory. However, the implications of a terrorist attack on a uranium store or on uranium in transit, or the misappropriation of the material, are such that these have to be taken account of in storage arrangements. The volume of the low activity uranium stockpile appears to militate against new centralised storage on transport and cost grounds. CoRWM therefore believes that the management of uranium should be the subject of a study that identifies the best balance between avoiding transport and achieving secure storage.

ILW and CoRWM's LLW

54. A large proportion of current holdings of these wastes is already being stored at Sellafield and Dounreay. As decommissioning and clean-up proceeds at these sites, further stores will be required, but there seems little reason for these wastes to be moved elsewhere until a repository is ready to receive them.

55. Operational and decommissioning wastes are also stored or will arise at other sites around the UK. The NDA is considering a number of issues such as coastal erosion, site stakeholder end-site aspirations, public acceptability, waste conditioning and reduction techniques, transport implications, and security, in developing its strategy for the treatment and storage of these wastes, including the possibility of consolidating storage on a smaller number of sites. In addition, it will need to assess the implications of the mis-match between its aspiration to achieve the decommissioning of nuclear power stations within 25 years of closure, and the sort of timescale within which a repository might be constructed (potentially around 40 years from now).

56. Some of the decommissioning waste will be short-lived ILW which might be suitable for non-geological disposal. If this form of disposal is implemented for LLW at or near existing nuclear sites, consideration should be given to whether a publicly acceptable safety case can be made for including short-lived ILW in the same facility. This would reduce the need to transport this waste away from the sites for geological disposal elsewhere.

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Chapter 17 Implementing a management strategy

CoRWM's recommended long term management strategy can only be implemented successfully if communities are willing to be involved. Proposals for implementation indicate new and innovative ways of working with communities in the UK based on concepts of fairness, enhanced well-being and participation in decision making. This chapter presents CoRWM's recommendations for moving forward including advice on the partnership approach that, in the Committee's view, must define the relationship between potential host communities and the implementing body.

1. CoRWM's terms of reference invited it to consider such issues as 'whether local communities should have a veto or be encouraged to volunteer, and whether they should be offered incentives'. In response the Committee has developed its ideas on how its recommendations can be implemented. The detailed proposals, together with an analysis of how they were developed, are set out in the accompanying report on "*Moving Forward: CoRWM's Proposals for Implementation".*[1] CoRWM's overall approach to implementation is embodied in the series of recommendations 9 - 15 which are set out in the Overview and in Chapter 14. This chapter presents the context for CoRWM's recommendations on implementation which form an integral element in the package of proposals presented for Government to act upon. On the basis of its research and knowledge, the Committee considers its proposals for implementation will be both politically feasible and publicly acceptable.

2. In arriving at its proposals for implementation, CoRWM has drawn on overseas experience where progress has been made in a number of directions. While direct transfer of overseas experience may not prove possible in a UK context, there is considerable scope for the application of concepts, ideas and processes that are being developed elsewhere. Members have visited some countries specifically to gain insight and understanding of processes that are being introduced to ensure the successful implementation of programmes. The Committee has also engaged specialists as well as using its own expertise. A workshop was held for the Committee to discuss and develop its thinking on implementation. It has also sought views on implementation during its engagement with the public and stakeholders.

3. CoRWM's approach to implementation is novel in a UK context. The starting point was the failure of all previous attempts to make progress. Having explored the possibilities CoRWM concluded that the only way forward was through a process whereby communities were willing participants in a process which recognised them as equal partners with the implementing body. Moreover it was taken as axiomatic that communities should benefit from the process gaining in well-being both now and in the future. By 'well-being' we mean those aspects of living that contribute to the community's identity, development and sense of positive self-image. Well-being is a broad concept and not narrowly defined in terms of financial incentives or community facilities. A community's well-being may be realised in a variety of ways through economic development, through greater control over its affairs and through an ability to define and realise its own vision for its future. CORWM's recommendations on implementation apply to the implementation of geological disposal. In addition, it is clear from the views of some stakeholders that the recommendations on implementation must be applied to at least new central or major regional stores at new locations if CoRWM's recommendations are to inspire public confidence. The extent to which they may be applicable to other new stores and changes to existing stores is a matter for further consideration.

General Principles for Implementation

4. The Guiding Principles that CoRWM developed for its process of selecting a long-term waste management option are considered to be equally applicable to the implementation process.

5. Experience in the UK and abroad clearly demonstrates the failures of earlier 'top down' mechanisms (often referred to as 'Decide-Announce-Defend') to implement long-term waste management facilities. The principle of ensuring that the potential host communities are willing to participate in a programme to implement a repository has been an essential feature of the programmes to construct a repository for spent nuclear fuel waste in Finland and Sweden and the programmes to implement repositories for both low-level and high level waste in Belgium. It has also been an essential feature of the repository programmes in Japan and South Korea. In Finland and Sweden, the decision to be a willing community was expressed by the municipal councils. Members visited Sweden and Finland in 2004 to understand the processes that were adopted and were impressed by the high level of trust that both the local councils and the communities had in the national waste management organisation and in the national regulator.[2] The latter was seen as a guarantor that the safety of both the public and the workers would be ensured.

6. It is generally considered that a voluntary process is essential to ensure equity, efficiency and the likelihood of successfully completing the process. It has taken a number of years and many failed siting attempts for this to become widely accepted although it had already become apparent in the 1990s.[3] There is now a growing recognition that it is not ethically acceptable for a society to impose a radioactive waste facility on an unwilling community. CoRWM believes that

   - *engagement with local communities must be an integral and continuing element in any implementation programme; and*

   - *involvement in any proposals for the siting of long-term radioactive waste facilities should be based on the principle of volunteerism, that is, an expressed willingness to participate.*

7. However, for potential host communities to be willing to participate in a siting process, overseas experience shows that they must be provided with adequate resources in an Involvement Package designed to enable communities to engage effectively in the process[1]. There must also be an opportunity for them to negotiate a Community Package that will provide the support to help to ensure the facility continues to be acceptable.[4, 5] As a result, CoRWM considers that the following general principle should apply in the development of an approach designed to encourage community participation in the process to implement its recommendations:

   - *Community Packages should be provided so that the well being of potential host communities will be enhanced in both the short and longer term.*

The Principle of Partnership

8. Some of the most promising programmes overseas are based on the potential host community working in partnership with an implementing body to achieve a successful outcome for both. Belgium has proceeded furthest in developing and implementing partnerships which relate to the provision of low level waste facilities.[6, 7] This initiative followed earlier attempts which had been opposed by municipal councils and the public. In this respect the Belgian experience is closer

to that of the UK than the Scandinavian experience. Members visited two of the Belgian partnerships in 2005 and, based on their report, the Committee concluded that the Partnership approach should be the model for implementing a repository in the UK. The low-level waste programme in Belgium led to the announcement of the site for a low-level waste repository in 2006 and the Partnerships have been re-formed to address the issue of a repository for high level waste.

9. One of the advantages of the partnership approach is that it achieves an environment in which host communities can engage with an implementing body without feeling victimised by a national process over which they ultimately have little control[8]. CoRWM therefore believes that a partnership approach should be developed in order to achieve community involvement. Partnerships should be based on an open and equal relationship between the potential host community and the implementing body.

10. The principle of equity (in other words the idea of fairness) requires that, although individual communities will have different interests and needs, the process of establishing and supporting partnerships should not favour or disadvantage any type of community. To avoid this, it is necessary that the basis of the involvement should be framed and agreed on a national basis, in a consultation involving the public and all relevant stakeholders. This basic framework should include the partnership arrangements, which need to be developed nationally with all the interested parties but be flexible enough to accommodate the requirements of local communities.

11. The question of who should represent community interests in the partnership is a matter that will require discussion with relevant members of the public and stakeholders. It is important that the partnership includes a wide representation within the community and that it reflects the full range of interests in the community as far as practicable. In this regard, representatives may be drawn from within the host community and also from among those whose interests embrace a wider area.

Involvement and Community Packages

12. On the basis of its investigations, CoRWM has concluded that communities are unlikely to come forward or agree to engage unless a comprehensive Involvement Package is provided, which will, in turn, allow the negotiation of a Community Package.[1, 9] The Involvement Package must provide the necessary resources to enable participation. CoRWM therefore concludes that the agreement of an Involvement Package should be regarded as a condition of proceeding with the partnership.

13. In developing Involvement Packages it is important to demonstrate that all communities are on an equal footing and that certain areas or regions are in no way being targeted because of their relative economic status.

14. An Involvement Package should contain enough support for the potential host communities during the site selection process to ensure that they have the necessary resources to be involved in a meaningful and effective manner. This should include the ability of the Partnership to engage effectively with the community and to obtain independent advice and review of the proposals made by the implementing body.

15. For the process to be fair, a local community hosting a facility should be better off after siting than before. This reflects and acknowledges the service that is being provided for society at large.[10] A fair outcome requires, therefore, the local community's agreement on an acceptable Community Package. Research

suggests that communities rarely regard monetary incentives alone as a means of offsetting the loss imposed by a newly sited facility where a potential hazard is posed[11].

16. Provision should therefore be made for the negotiation of a Community Package to support the well-being of the community in the short and long-term and it must take into account the well-being of future generations as well as that of the present.

17. International research shows that it is important that the host community has a sense of ownership of the facility that will be built and is therefore involved as early as practicable in the generic technical aspects of the design.[12,3,4] CoRWM therefore concludes that representatives of the potential host communities should be involved in determining both the broad technical aspects of the proposed facility as well as the socio-economic aspects aimed at ensuring the well being of the community.

18. While the scale and scope of the funding to support the implementation process will need to be determined nationally in discussion with relevant parties, it is important that the Partnerships have the ability to determine how they make use of the resources included in the Involvement and Community Packages. They should have the freedom to determine the work programme, and the distribution of funds for the range of purposes agreed. It follows that the budget for the Involvement Package should be agreed with the relevant funding organisation before communities are invited to become involved. It must be accepted that safeguards will need to be incorporated into the process to avoid the misuse of funds.

Identifying potential host communities

19. Deciding how a potential host community should be defined will not be straightforward. One reason for this is that relevant communities may not coincide with local authority boundaries. Consequently CoRWM considers there should be scope for communities to be self-defining in terms of an initial willingness to participate. This has also been proposed in Germany.[7] There is also the question of who should represent the community. This is a matter for further consideration. Whoever represents the community, the decision to participate and subsequent proposals developed through partnership arrangements must be ratified by the appropriate elected representative body/bodies. However, in some parts of the UK, the areas that are covered by local authorities are so large that it may prove difficult to resolve conflicts between potential host communities and the wider area. In such cases, special arrangements for the ratification for the Partnership's agreement may be necessary.

20. In principle, every community should have the right to express a willingness to participate in the process but, in practice, some areas may be scientifically unsuitable for a waste facility. To ensure a fair process and create confidence, it is important that such areas are screened out before communities are invited to express a willingness to participate.

21. In many cases in the past, centralised authorities developed the screening criteria and stakeholders, including potential host communities, were unable to influence them. There is now growing evidence internationally that communities will only come forward or accept invitations to take part in the process if the criteria themselves are subject to open discussion and engagement.

22. CoRWM therefore concludes, that before any invitation to participate is issued, the screening criteria should be developed through an open and transparent engagement process. These broad criteria should be applied to screen out those

parts of the country where radioactive waste facilities would be unacceptable on scientific grounds. Within the remaining territory all communities that wish to express a willingness to participate should have the opportunity to do so. However, there should be no presumption that areas that have not been screened out are therefore suitable as locations for radioactive waste facilities. Suitability will depend on further scientific investigations.

23. In processes that are successfully moving forward abroad, the right of the potential host community to withdraw from the process is an important factor in determining the willingness of communities to participate.[1, 13, 14, 15] This right has some limitations. There will come a point when the process of implementation has proceeded so far that withdrawal would not be possible. Accordingly, CoRWM proposes that potential host communities should have the right to withdraw up to a pre-defined stage in the implementation process. The precise point at which a community might lose the right to withdraw requires further study.

24. Potential host communities are not the only local communities that need to be involved in decisions on the siting of waste management facilities. Principles of equity dictate that affected communities outside the local host community, such as those along transport routes, should also be involved in some way.[9, 16, 17] CoRWM is clear that there should be arrangements that enable affected communities outside the host community to be involved in the process if they so wish.

25. The implementation process will involve decisions that need to be taken at different levels. What screening criteria should be applied, the framework within which Partnerships will be established and the general structure and resources for packages are examples of decisions that that must be taken at the national level. Other decisions, such as expressing a willingness to participate and what constitutes an acceptable Community Package, are clearly to be decided at a local level. The appropriate level for some decisions is less clear and requires further discussion but, as a general principle, it is considered that decisions should be made at the lowest appropriate level.

Staged Process

26. Experience from overseas shows that implementation should be carried out through a staged process of sequential decision making.[18] The basic structure of staged decision making has been set out by the Nuclear Energy Agency:[19]

> '...development is by steps or stages that are reversible, within the limits of practicability. In addition to the institutional actors, the public, and especially the local public, is involved at each step and also in review of the results of decisions taken in a previous step. This is designed to provide reassurance that decisions are made in a transparent manner and can be reversed if experience shows them to have unexpected and unacceptable adverse effects'.

27. Some suggestions on the major stages and the roles of the main organisations in each stage are made in the text of the full Implementation Report. CoRWM concludes that any future implementation process should incorporate a staged decision making process which has the following elements:

- *Key decision points set out as milestones with opportunities for review.*

- *The main elements and stages in the process set out before the process starts, with clear and transparent roles for the participants. This does not mean that the process cannot be flexible but, if changes are made, they should be made with the involvement and agreement of the participants.*

- *At the end of each stage, there needs to be an agreement between the relevant parties to proceed, which is ratified by the elected decision making body/bodies, before proceeding to the next stage.*

- *The points at which there is a right to withdraw from the process should be clearly defined in advance.*

- *In order to be efficient and conclusive, the process should involve milestones at which major decisions will be made, which can be consolidated and only reversed subsequently by an agreed process or regulatory decision.*

Institutional Arrangements

28. Given the long history of delay and deferment in the UK on the issue of radioactive waste management, it is clear that any new or revised institutional arrangements for progressing the radioactive waste management process in the future need to draw on the current goodwill and momentum achieved by the CoRWM process. There is a pressing need to establish an appropriate institutional basis to carry the process forward.[20, 21, 22, 23]. It is CoRWM's view, strongly supported by the public and stakeholders, that the staged decision-making process should be supervised by an independent body with overall responsibility for overseeing the research and development programme and the siting strategy. Government should set up such a body without delay.

29. An integral part of the remit of the overseeing body should be to ensure that there is proper engagement with the public and stakeholders at each stage. Engagement must be conducted openly and transparently, so that the siting process inspires the confidence of all those involved.

30. There should also be an implementing body responsible for the construction and operation of any necessary facilities, and related research and development.

31. The roles of the overseeing body and the implementing body at each stage of the decision making process must be clearly defined in advance.

32. The involvement of the regulators has been crucial to the success, to date, of the implementation process in Sweden and Finland.[1, 18] In contrast, the lack of involvement by the environmental regulator in the process leading up to the Planning Inquiry into the rock characterisation facility at Sellafield has been heavily criticised.[20] CoRWM concludes that the environmental regulators should be involved in the implementation process at a very early stage and should continue to be closely involved throughout the process.

Future Work

33. The Implementation Report[1] provides a set of proposals which, CoRWM believes, will enable its recommendations for radioactive waste management to be carried forward. The proposals for implementation indicate new and innovative ways of working with communities in the UK based on concepts of fairness, enhanced well-being and participation in decision making. The basic principles set out here have to be transformed into working practice and CoRWM recognises there is considerable further work to be done. Throughout the report, CoRWM has identified areas for future work and the PSE process has indicated areas which need to be clarified or developed if a successful implementation process is to be achieved. The Committee sets out the areas for further work below.

National and local decision making

34. This concerns the level at which decisions should be taken. Among the areas for consideration here are: screening and siting criteria; invitations to participate; rights of withdrawal; setting up an institutional framework; framing of partnerships; allocation of resources; definition of packages; setting out stages in decision making. The process of implementation must begin at national level but the extent of subsequent devolution to local authorities and partnerships needs to be determined. Legal and administrative procedures (e.g. the planning process) will also need to be considered.

Screening

35. There will need to be early decisions on the criteria for screening out those parts of the country ineligible to participate in the implementation process. What kinds of criteria should be employed, how fine or coarse will the screening need to be? An issue here will be whether to use mainly scientific and technical criteria to define areas where geological disposal may be possible or to identify criteria that take into account the possible constraints on storage.

Identification of communities

36. This covers a number of issues including how to define host communities, whether and how they might be self-defining, how to inform communities and how to confirm a willingness to participate. How far should the interests of affected communities be taken into account?

The nature of partnerships

37. The membership, role and responsibilities of the potential host communities and the implementing body within each Partnership need to be determined. The extent to which existing regional and local strategic partnerships could provide the basis for the representation of the potential host community, and how the adequacy of the representation is judged, need to be considered. The size of each Partnership, which has to be both workable and adequately representative, needs to be established. There is also a need to determine a suitable structure, the membership of the executive body, the number of working groups, the issues that should be addressed and the time that each Partnership would reasonably require to complete its work.

The concept and composition of packages

38. The roles and potential content of Involvement and Community Packages need clear definition. There needs to be consideration of how budgets are to be established, sustained and administered. Where does budgetary decision making power reside? The possible constraints or opportunities relating to state aid will need to be considered. A significant issue will be whether the proposals create precedents and, if so, what are the implications of this.

Democratic representation and ratification of decisions

39. This is recognised to be necessary to achieve overall acceptability and legitimacy for decisions. What decisions require democratic endorsement, and at what level, requires further work. For example, where should authority lie for the decision to participate, the decision to withdraw or decisions about budgetary allocations? Should ratification be obligatory if decisions are endorsed by communities or partnerships? What rights of appeal or override might there be? A key issue is

how the interests of host and affected communities and partnerships can be democratically represented within local government decision making.

Staged decision-making

40. At an early stage in implementation, it will be necessary to set out the stages and key decision points and responsibilities for taking key decisions. There should be an indicative time-scale for decision-making and clear allocation of roles for achieving objectives.

Institutional context

41. The roles, responsibilities and membership of the overseeing and implementing bodies should be established at an early stage.

Planning and regulatory framework

42. An important question is how the CoRWM proposals relate to the planning and regulatory processes, including the implications of the requirements for Strategic Environmental Assessment.

Overseas experience

43. CoRWM has given detailed consideration to overseas experience in how communities are invited to express a willingness to participate, how this decision is made at the local level, partnerships and community packages. During implementation it will be important to continue research on developments in other countries.

Implementation plan

44. An early task (see also Chapter 19) will be to set out an implementation plan identifying priorities and resources. There will be a need for CoRWM and its successors to establish close working relationships with sponsoring Government departments and the devolved administrations as well as with key stakeholders. It is axiomatic that the open and transparent processes through public and stakeholder engagement must be continued if progress in implementation is to be maintained.

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Chapter 18 Addressing uncertainties

The future is inherently unpredictable and uncertain. Policy decisions need to be robust against reasonably foreseeable contingencies. CoRWM considers that uncertainties are a central issue in the long-term management of wastes that will remain significantly radioactive over many thousands of years. It believes that, from the outset, relevant uncertainties need to be identified and, as far as possible, managed. In this chapter, CoRWM identifies the main uncertainties, explains their possible consequence for the long term management of radioactive waste and, where possible, proposes how to address them.

1. CoRWM has based its recommendations on the best available information obtained from its review of the literature, contacts with specialists and engagement with the public and stakeholders. It believes that its recommendations are sound and robust when judged against this knowledge base. However, it acknowledges that there are limitations and uncertainties. These apply to both disposal and storage options. Previous chapters (8, 11 – 13) explain how CoRWM took account of these limitations and uncertainties in coming to its recommendations. This chapter considers the nature of the uncertainties in more detail and addresses ways to deal with them.

2. Decision makers can never know everything that could happen. This inability to predict the future with certainty is a particular problem when planning for the long term management of radioactive waste because of the need to model the performance of options over many thousands of years. CoRWM believes that it is important to identify and address uncertainties from the outset but recognises that it will not be possible to eliminate them altogether. Nevertheless, CoRWM believes that it is important to spell them out clearly so that proper consideration can be given to management in the face of continuing uncertainties.

3. The way in which uncertainties are addressed is, and will continue to be, closely linked to the public's confidence in proposals for the long term management of radioactive waste. People want to know the risks and benefits involved and they are more likely to have confidence in a proposal if the uncertainties surrounding these risks and benefits are spelled out and the approach to dealing with them is clearly explained.

4. In this chapter, CoRWM identifies the main uncertainties, explains their possible consequences for the long term management of radioactive waste and, where possible, proposes how to address them. The causes of uncertainty are many and varied and they cover both our current scientific and social knowledge. CoRWM found it helpful to group these for discussion purposes.[1] The chapter starts with the uncertainties over the inventory stemming from present Government policy initiatives and then looks at the uncertainties inherent in CoRWM's proposals for implementation. The next sections look in more detail at uncertainties relating to the performance and siting of facilities and the implications of possible future developments in science and technology. Finally there are some comments on uncertainties relating to institutional control in the future.

Uncertainties over the inventory for disposal

5. CoRWM's recommendations make some assumptions about the inventory for disposal. CoRWM's baseline inventory is described in Chapter 2 and in its Inventory Report.[2] However, CoRWM's remit covers only one aspect of radioactive waste management. Developments in other policy areas relating to the issues outlined below may also have an impact on the way in which CoRWM's

recommendations are taken forward because they will affect the inventory and the time when waste will be ready for disposal. The impact could be significant and could have consequences for the implementations of CoRWM's recommendations on storage and disposal.

6. The Government has now stated that it "believes nuclear has a role to play in the UK not only in reducing emissions but also to maintain the diversity or our electricity generation mix".[3] CoRWM is emphatic that the management of waste arising from a new build programme should be the subject of a separate process (Chapter 14). CoRWM members are unanimous in their view that the results of CoRWM's PSE programme cannot be taken to provide an endorsement that its recommendations should also apply to wastes from new build.

7. CoRWM made some baseline calculations on the volumes of extra waste that might need to be managed under a new build scenario so that it could obtain a better understanding of the waste inventory (Chapter 2). If a decision is made to build new power stations, there will need to be a detailed assessment of the waste inventory that will arise so that proper arrangements can be made for its management. At the very least, there could be an effect on repository design and size; there may also be a need for more management facilities including interim stores at new reactor sites. The construction and operation of a new generation of nuclear power stations will make it difficult to define a waste inventory once and for all; there will be uncertainties over the volumes of waste and the timescale over which they will be generated.

8. Similar uncertainties exist in relation to those materials that are currently regarded as having potential future uses rather than as wastes, namely spent nuclear fuel, uranium and plutonium. CoRWM has estimated the impact on the inventory if these are declared as waste but there are also wider issues of societal concern. The amount of these materials, both relative to each other and in absolute terms, will be determined by the extent to which they are used as fuel in nuclear power generation either directly or following reprocessing. The uncertainties over the possibility of a new generation of nuclear power stations are relevant here as well. It is CoRWM's view that communities are unlikely to express a willingness to participate in a siting process unless they have a clear understanding of the waste inventory they may be asked to accept.

9. The outcome of the review of LLW management[4] could have implications for the disposal of short lived ILW comprising reactor decommissioning waste. There may be opportunities to treat decommissioning LLW and some ILW waste streams together, thereby avoiding the need to put reactor decommissioning waste into a repository. A decision on this matter will be important in resolving uncertainties over the inventory of waste destined for geological disposal.

10. The consultation on the management of redundant nuclear submarine reactor compartments, ISOLUS,[5] took account of the fact that CoRWM's recommendations would be of relevance to this waste, for which the Ministry of Defence (MoD) is currently responsible. It will be for Government to decide how this waste is to be managed; until this is done there will be uncertainty over whether or not this waste is destined for geological disposal and, if so, how it will be managed in the interim.

Uncertainties relating to CoRWM's proposals for implementation

11. CoRWM has made a number of recommendations relating to the implementation of a long term waste management programme (Chapter 17). These focus on the need to identify a volunteer host community or communities to host a radioactive waste facility through a process in which communities that are willing to participate in site selection are engaged in a partnership. The rejection of the

previous 'decide-announce-defend' approach in favour of full public participation has implications for the timing of the implementation programme. While the old approach appeared to allow Government to keep full control of the process and impose a timeframe, the reality is that the process was likely to stall at any stage because of public resistance, throwing the programme off track. The staged approach proposed by CoRWM allows for the fact that it will be impossible to impose a fixed timeframe on the process but, because the overall approach is laid out from the start, it will be possible to measure progress and adapt timelines in response to the rate of progress at each stage.[6]

12. There are several ways in which uncertainties arising through the implementation process could be addressed. Much will depend on the quality of the public and stakeholder engagement that is used. It is essential that this should be open, participatory and fully inclusive and conducted in a way that recognises the status of the public and stakeholders as partners. A full and continuing commitment to the need to obtain the agreement of a host community is important. If a first round of engagement with communities willing to participate in the process fails to achieve a satisfactory outcome, there should be a commitment to go back a stage and try again; a return to 'decide-announce-defend' should not be an option. CoRWM recognises that progress with obtaining the agreement of a volunteer host community might be slow and that, in the worst case, it might be impossible to achieve at the moment. This is one of the reasons for CoRWM's recommendation that geological disposal should be seen alongside interim storage as part of an integrated management programme. The provision of facilities for interim storage will not only ensure that the wastes are managed properly until such time as a repository is available; it will also take some of the pressure off the process of site selection. It is important to proceed at a pace commensurate with the need to develop and enhance trust and confidence in a potential host community, rather than push forward plans for a repository against a fixed timetable.

13. CoRWM's Implementation Report[6] raises some of the uncertainties associated with a participative approach to site selection including defining what a 'community' is; how a community might express a 'willingness to participate'; and how a 'right to withdraw' might operate. The Committee recognises that there is a need for further work to flesh out the details of its implementation proposals and to address the uncertainties.

Uncertainties over the performance of repositories and stores

14. The regulatory regime in the UK requires the production of a satisfactory safety case before a facility for waste management can obtain a licence. The safety case for a repository will have to include an assessment of its performance over very long time scales. The assessment will be based on detailed knowledge of the local geology coupled with modelling of the performance of the component parts of the engineered barriers. Confidence in the safety case is crucial to the acceptability of a repository. The extent to which people have this confidence – even in the general concept of a repository, without looking at specific proposals – varies considerably from individual to individual and from sector to sector. These differences in perception of the reliability of calculations about long term safety account, in large part, for a preference for disposal over storage or vice versa.

15. It is essential, therefore, to reduce the uncertainties as far as this is possible. As part of the implementation programme, further scientific research should be undertaken to gauge the extent of the uncertainty around any particular aspect of repository design and then attempts should be made to reduce the uncertainties by improving the data that are fed into the models. It will be necessary, in this respect, to make full use of information obtained from overseas rock laboratories and from investigations into natural analogues.

16. It will be important to convey information to the public; people will want to know what the uncertainties surrounding predictions are and how confident the scientists and other technical specialists are in their assessments. They will also want to know what the consequences would be if the scientists have got it wrong. Where there are differences in scientific opinion, these should be fully aired. The use of joint fact finding exercises, in which those disputing the interpretation of data work together in an attempt to resolve the differences, is one way in which these issues can be explored in a non-confrontational manner.

17. Geologists and other scientists have expressed confidence in the generic concept of geological disposal (Chapter 13). However, there is only so far that scientists can go in reducing uncertainties in a generic concept. Much will depend on information gained from site investigations. Again, it will be essential to involve potential host communities in research programmes so that their concerns can be addressed. Because site investigation is so costly, there is a danger that the public will perceive it as an exercise with a pre-determined outcome, i.e. to demonstrate the suitability of the site for a repository. To avoid this, there needs to be a clear set of detailed objectives agreed prior to commencement in order to allow the public to understand what the purpose of the investigation is and how the data will be used.

18. One of the main areas of uncertainty around geological disposal raised during CoRWM's work, including its PSE programme, was the robustness of the repository concept, where questions were raised over the performance of the engineered barrier, the extent to which the geology can be relied on, groundwater modelling and the extent to which radioactive gases will be retained. Serious concerns were also expressed over the impact of any release of radioactive waste into the biosphere at some time in future. Here there are concerns that our current understanding of the impacts, especially of low level radiation, is incomplete. Taken together, these two areas of uncertainty can lead to an overall lack of confidence. CoRWM believes that confidence could be built if more effort was put into reducing the uncertainties through further research and explaining the implications of any new information.

19. No amount of site investigation or computer modelling can resolve all uncertainties about the future, especially in the very long term. We cannot know what the biosphere will be like hundreds of thousands of years from now and we cannot know what human communities will be like, if they exist at all. These uncertainties need to be acknowledged openly and the public needs to know how they are being addressed, through the use of worst case scenarios or other approaches. Again, joint working could be utilised, giving the public the opportunity to ensure that their concerns are addressed and their questions are answered.

20. Before approval is given for the construction of any repository, the regulators will have to accept the safety case submitted by the body responsible for implementation. CoRWM recommends that the regulators should be involved at the earliest possible stage so that the safety case can be built on a firm foundation of knowledge and regulatory expectations. It will be important for both the implementing body and the regulators to keep the public fully informed as the process goes on, explaining what the areas of uncertainty are and how they are being addressed.

Siting of Facilities

21. CoRWM's recommendations allow for the possibility of facilities on or near to existing nuclear locations (Annex 4). This possibility is dependent on the suitability of the individual sites as a locality for facilities designed to last for over one hundred years (in the case of stores) or longer (for facilities for reactor

decommissioning waste). The implications of climate change, including sea level rise, increased risk of periodic flooding and coastal erosion, will have to be taken into account. If it is not possible to protect sites against these potential hazards, then local solutions will have to be ruled out. This situation could arise for a number of reasons. For example, it may prove impossible to come up with accurate enough climate change models to enable engineers to design an effective system of protection without leaving an unacceptable risk of failure because conditions turn out to be more extreme than predicted. Even if accurate predictions can be made, the engineering requirements may be too technically challenging or too expensive to be practicable.

22. While, broadly speaking, stores could be built anywhere where the surface conditions are likely to be stable for a long enough period, the siting of a repository is constrained by the nature of the geology. The success of CoRWM's proposals for the implementation of its recommendations on geological disposal is dependent on there being one or more willing communities with a suitable geology. Even if those areas of the UK with unsuitable geology are eliminated before the search for a community begins, there will be no guarantee that the geology at any particular site will be suitable.

23. The major public concern expressed to CoRWM is that radioactivity will leak back to the surface when water gets into the repository. The site investigations are, in part, designed to address this issue by attempting to model the groundwater flow. This is a highly technical and specialised task that is difficult to explain to the lay person. The uncertainties over the geology could have implications for the implementation programme. Site investigations are expensive and it is unlikely that the implementing body will be able to carry out detailed work on the geology at more than one or two sites at a time. If these investigations show that the site or sites are not suitable, there will be a delay while another site is investigated (assuming there is a willing host community). The cynical view would be that the implementing body would seek to avoid having to do this and would make the best of the geology at the site or sites investigated. Because the nature of the investigations is complicated and covers a range of different topics, the potential for the public feeling that they have been deceived is high. It will be essential to provide a clear demonstration that this is not the case. The best way of doing this is to involve the host community partnership in the details of the site investigation from the start and take care to explain the implications of the results of the investigations as they go along. If it can be shown that the regulators are in agreement with the conclusions drawn from the investigations this would also go some way towards reassuring the public.

Uncertainties over Future Scientific Understanding and Technical Developments

24. Current assessments of the long term performance of the waste management facilities recommended by CoRWM are based on the assumption that the basic scientific premises will not change but that it will be possible for performance to be more tightly defined and assessed as a result of improvements in modelling as more data become available. However, it is also possible that scientific research may lead to changes in our understanding of the behaviour of radionuclides or on their impacts on human health and on the environment. Also, further research might lead to technological developments that could provide alternative, possibly better, options for management.

25. The system of radiation protection adopted internationally makes use of dose coefficients in assessing the health risks from radioactive emitters taken into the body. These dose coefficients relate intakes of radionuclides to radiation dose, which is intended to provide a measure of the potential for harm, taking into account the harmfulness of different radiations and the sensitivity of different body tissues and organs. Reference values are published by the International

Commission on Radiological Protection (ICRP).[7] There are differences of opinion, however, as to whether uncertainties have been adequately addressed in the current system of protection. In addition, it is not possible to know what levels of exposure to radiation future generations will regard as acceptable.

26. One issue of particular concern for some people, is the possibility that our current understanding of the impacts of low level radiation is incorrect and that, in particular, current standards are based on an under-estimate of the risks invo

27. lved.[8] On the other hand, standards have also been criticised for being over cautious.[9] It is probably unrealistic to think that these differences of opinion can be resolved to the satisfaction of all parties. However, it is generally acknowledged that scientific understanding of the biological effects of radiation is incomplete. Where there are uncertainties that could be reduced by further research, it is important that these should be addressed so that new data can be fed into the modelling of the performance of geological disposal concepts.

28. Some of the options on CoRWM's long list were rejected because they were not sufficiently well developed for CoRWM to have confidence in them (Chapter 10). Similarly, in its assessment of the short-listed options, CoRWM concluded that the use of boreholes as a form of geological disposal for some types of waste could not be recommended at this time but that improvements in technology might make it more attractive in the future (Chapter 11). CoRWM has made specific recommendations on the UK's involvement in research into the development of other options (chapter 14). The relatively long timeframe for the implementation of a repository provides the opportunity for such developments of other options to be taken into account before final decisions on disposal are made.

Uncertainties over institutional control

29. The uncertainties outlined above are mainly concerned with the lack of scientific knowledge and confidence in the models used to predict performance. There is a further set of uncertainties relating to the nature of human society in the future. CoRWM's work on intergenerational equity demonstrated how difficult it is to know what the right thing to do now is, given that we do not know the conditions under which future generations will live or what their needs and aspirations may be. Nevertheless, it is necessary to acknowledge that the future will not look like the present.

30. At the most basic level, it is important to note that both interim storage and the pre-closure phase of geological disposal are dependent on institutional control and any assessments of performance will have to consider the consequences of a break in that control.

31. The prospect, nature and societal implications of a loss of institutional control are unknowable and cannot be made more certain. However, it is possible to address the implications of a loss of institutional control on the performance of a facility. Most importantly, work is needed on the design of facilities with as little reliance on institutional control as possible; further research into enhancing passive safety and security of facilities would be a step towards addressing this need.

Conclusion

32. If the public are to have confidence in the proposals for the long-term management of radioactive waste, it is essential that the areas of uncertainty and the plans for addressing them are clearly identified from the outset. Wherever possible, uncertainties should be reduced through further research. Where this is not possible, the implications for the success of the programme should be

explained along with proposals for managing the programme in the face of these uncertainties.

References

1 Committee on Radioactive Waste Management, "Top-level review of main uncertainties, potential show-stoppers, associated actions and possible contingencies" CoRWM Document no. 1687, 2006.

2 Committee on Radioactive Waste Management, "Radioactive Wastes and Materials Inventory", document 1279, July 2005.

3 Department of Trade and Industry, "The Energy Challenge: Energy Review Report 2006", page 8. See also DTI website http://www.dti.gov.uk/files/file31890.pdf

4 Department for Environment, Food and Rural Affairs & others, "A Public Consultation on Policy for the Long Term Management of Solid Low Level Radioactive Waste in the United Kingdom", February 2006. See also Defra website http://www.defra.gov.uk/environment/radioactivity/waste/index.htm

5 Ministry of Defence, "Interim Storage of Laid Up Submarines: Consultation on ISOLUS Outline Proposals: Ministry of Defence Response to Lancaster University's Final Report", February 2005. See also ISOLUS website http://www.lancs.ac.uk/users/csec/isolus2/isolus%20history

6 Committee on Radioactive Waste Management, "Moving forward: CoRWM's proposals for implementation", document 1703, July 2006

7 see ICRP website http://www.icrp.org

8 see for example the Low Level Radiation Campaign website http://www.llrc.org/

9 Committee on Radioactive Waste Management, "Criteria Discussion Paper 1: Safety", IDM 21/1 Butler et al, June 2005

Chapter 19 Next steps

The publication of the CoRWM recommendations is a key point in the Government's 'Managing Radioactive Waste Safely' (MRWS) programme. There are a number of steps that should be taken as soon as practicable so that the momentum that has now been established in the MRWS programme is not lost.

1. As described in this report, attempts to implement policy for the long-term management of the UK's higher activity radioactive wastes have been protracted, inconclusive and unsuccessful. As part of the Managing Radioactive Waste Safely programme, CoRWM has spent over two and a half years conducting a wide-ranging study and assessment of options for dealing with these wastes. During the Committee's public and stakeholder engagement programme, CoRWM was told repeatedly that it was imperative for Government to respond to the recommendations quickly and begin the process of implementation as soon as possible.

2. There are a number of actions that need to be taken to ensure that momentum is not lost, and that there is a smooth transition from Stage 2 of the MRWS programme to Stage 3. This chapter does not list all the actions required, but provides a guide to the key initial ones.

Set out a Long Term Waste Management Policy

3. CoRWM urges Government, after considering these recommendations, to make a decision on its long term waste management policy as soon as is practicable.

Set up an Overseeing Body

4. In order to put policy into action, the Government needs to appoint an independent Overseeing Bbody. This body will help to drive the implementation programme forward in the early stages. The immediate actions needed are therefore to:

   i. Develop the terms of reference for the Overseeing Body

   ii. Appoint members

   iii. Review support requirements, including specialist staff

Establish an Implementing Body

5. Once the nature of the policy has been decided, Government will be in a position to decide what body, existing or new, should implement the proposals. This decision should be made as early as possible so that implementation planning can proceed.

Define the steps in a Staged Decision-Making Process

6. The implementation of CoRWM's recommendations will involve a complex series of steps and relationships with other agencies and programmes. It will be essential to set out the stages and to identify what decisions will be needed by when and by whom. While this process will, by its very nature, be iterative, clarity will be needed at an early stage about some of the anticipated major decisions.

Undertake a review of storage

7. Government and the NDA should ensure that current arrangements for storing waste are appropriate in the light of the recommendations and observations in this report. In addition, decisions must be taken about when and where new stores are to be constructed.

Identify areas that are unsuitable

8. CoRWM has recommended that areas that are not suitable for radioactive waste facilities should be identified before communities are invited to express a willingness to participate in implementation discussions. The process of developing and applying scientific and other screening criteria to identify those parts of the country that are not suitable for a geological repository and/or new centralised stores should be commenced as soon as practicable, with appropriate public and stakeholder engagement.

Develop the framework for Partnership Arrangements

9. The framework for partnerships between host communities, the implementing body, (and others as required) should be decided at national level, but with public and stakeholder input. This will involve, amongst other things:

   i. Clarifying by whom, under what circumstances and through which mechanisms, a community's 'willingness to participate' can be expressed.

   ii. Developing the broad framework of Involvement Packages and Community Packages.

   iii. Establishing the relationship between partners, with particular reference to how the 'equal and open' relationship that CoRWM recommends will work in practice.

   iv. Agreeing funding arrangements.

   v. Identifying the points in the programme, and the conditions under which, the right to withdraw could be exercised, including identification of the point beyond which no withdrawal will be possible.

Establish an R&D Programme

10. An R&D programme should be established as soon as practicable after Government has given its response to CoRWM's recommendations. This should focus on intensifying research into reducing the uncertainties surrounding the long-term safety of geological disposal; and examining the way in which the means of storing waste in the relatively long term (100-150 years) can be improved. Research into increasing the lifetime and robustness of waste packaging should be included. In addition, arrangements should be made to monitor national and international R&D in the field of radioactive waste management with a view to identifying any promising developments in alternative management options.

Bridging Activities

11. CoRWM will be undertaking some post-recommendation work until later in 2006 and will maintain relationships with public and stakeholders during this time. The Overseeing Body, once established, should then maintain these relationships, keeping the public and stakeholders informed of progress with the recommendations. This is important if public confidence is to be developed further.

12. Further work on those areas of the Implementation Report that require clarification could be undertaken during this period (see Chapter 17).

Conclusion

13. There are a number of actions that can be taken relatively quickly to get the implementation of CoRWM's recommendations off to a strong start. By taking action within a reasonable time of receiving CoRWM's report, Government will be able to maintain momentum and continue to build public confidence.

Annex 1 Terms of reference

Objectives

1. CoRWM is appointed jointly by Ministers of the UK Government and devolved administrations of Northern Ireland, Scotland and Wales, to oversee a review of options for managing solid radioactive waste in the UK and to recommend the option, or combination of options, that can provide a long term solution, providing protection for people and the environment. This follows the announcement by the Secretary of State for Environment, Food and Rural Affairs to the UK Parliament, and by devolved administrations, on 29 July 2002.

2. CoRWM must ensure that this review of options is carried out in an open, transparent and inclusive manner. The process of review must engage members of the UK public, and provide them with the opportunity to express their views. Other key stakeholder groups with interests in radioactive waste management, must also be provided with opportunity to participate. The objective of CoRWM's programme is to arrive at recommendations which can inspire public confidence and are practicable in securing the long term safety of the UK's radioactive wastes. It must therefore listen to what people say during the course of its work, and address the concerns that they raise.

3. CoRWM will have a corporate responsibility to deliver its recommendations to sponsoring Ministers in accordance with agreed work plans. It must aim to supply recommendations to them no later than the end of 2005[1], and sooner if possible. It will be for Ministers, with appropriate reference to their respective Parliaments and Assemblies to decide future policy for the long term management of the UK's solid radioactive waste and to make arrangements for its implementation.

Committee characteristics

4 **Size of the Committee**. CoRWM will consist of a Chair, and 12 Members which will include a Deputy Chair.

5. **Composition of the Committee**. CoRWM will include people with a range of expertise: people with a perspective of environmental, health, social or ethical issues, as well as people with technical experience and expertise in radioactive waste matters. Ministers hope to find these skills and perspectives: radioactive waste, nuclear materials and how they can be managed; regulation of UK processes that give rise to radioactive waste; public engagement, consensus-building and resolving conflict on contentious issues; applying ethical principles to scientific and technical decision-making; national and international environmental law; scientific and technical issues such as earth science, materials and their properties, and civil engineering; radiation protection principles and their implementation; radionuclides and how they affect the environment; environmental, health and safety issues and how they interact and conflict.

6. All members will need to be effective team workers, with good analytical skills and good judgment besides a strong interest in the process of decision-making on difficult issues. A number of them will need experience of managing complex projects, drawing on public and stakeholder group involvement and discussion, excellent drafting and communication skills, or business experience and knowledge of economics.

[1] CoRWM agreed with sponsors in the summer of 2004 that it would report by July 2006.

7. The Chair, in addition, will be capable of successfully and objectively leading committee-based projects, grasping complex technical issues, managing a diverse organisation effectively and delivering substantial results, presenting progress and outcomes in public, a person with appropriate stature and credibility.

8. **Access to other sources of expertise**. CoRWM itself will have to decide how best to secure access to other appropriate sources of expert input during the course of its work. Within this, it will have option of setting up expert sub-groups containing both Members of CoRWM itself and other appropriate co-opted persons. A member of CoRWM will chair any sub-group of this nature and ensure its effective operation, as well as provide a clear line of responsibility and accountability to the main Committee, and hence to Ministers. This approach will enable them to draw on a broad range of expertise in the UK and elsewhere.

9. The number of such sub-groups will be kept to the minimum necessary. Their role will be that of providing advice for the main Committee to consider and assess as it sees fit, and managing any activity which CoRWM delegates to them. It will be for the main Committee to assess and decide upon the advice it receives from such sub-groups. CoRWM may also utilise other appropriate means of securing expert input, such as sponsored meetings and seminars. The Chair will ensure that sub-group work and all other activities are closely integrated with the Committee and with one another.

10. **Length of appointment**. Initial appointments will be for three years. Sponsoring Ministers retain the right to terminate appointments at any time in light of individual members' performance appraisal, changes in CoRWM's work requirements, or completion of the work required of CoRWM.

Programme of work

11. CoRWM's objective is to recommend to Ministers the best option, or combination of options for managing the UK's solid radioactive waste that can provide a long-term solution, providing protection for people and the environment. The UK's waste inventory contains, or will contain, a wide range of high and low activity, short and long lived wastes. CoRWM's priority task is to recommend what should be done with the wastes for which no long-term management strategy currently exists - that is, high and ILW now in storage or likely to arise over the next century or two, and some low level waste unsuitable for disposal at Drigg. However, for some of these wastes, the Nirex "Letter of Comfort" system has provided a framework which has enabled helpful progress to be made on conditioning and packaging. (Ministers have other sources of advice on other wastes for which a long term management strategy already exists but where there may be long or shorter term issues needing attention. CoRWM may wish to offer advice on these issues but this should not divert it from its priority task set out above.)

12. CoRWM will take a strategic approach to the review and assessment of options for the long term management of radioactive waste. It will start by gathering information and familiarising itself with the issues, including meetings and presentations as appropriate. The outline framework within which CoRWM is then expected to complete its work is:

Setting the framework for the review through identification, on the basis of sounding public and stakeholder views, of:

- the inventory of materials to be covered (this will include not only the materials currently classified as waste liable to arise over the next century or so but also materials which may have to be managed as waste during that period, such as some plutonium and uranium as well as certain quantities of spent nuclear fuel);

- the options for the long-term management of the various waste materials; and

- the criteria against which each of the options being carried forward to the main assessment are to be assessed. (These criteria are likely to be wide-ranging, reflecting among other things, the potential risks involved, concerns been expressed by the public and stakeholders, and practicability of implementing each option.)

13. CoRWM should take the earliest possible opportunity to identify those options which have no realistic prospect of being implemented within the reasonably foreseeable future, so that the main effort during the assessment stage can be focussed on those which are practicable.

14. **Implementation of the review**. This will involve evaluation of each of the remaining options, for each of the wastes concerned, against the agreed set of criteria. The assessment will take account of existing information and any new research that CoRWM judges necessary. An initial assessment report will be produced by CoRWM and subjected to appropriate soundings of public and stakeholder group views. A final version will then be produced taking due account of the views expressed.

15. **Formulation of recommendations**. The final assessment report will be used to formulate Committee recommendations to its sponsoring Ministers. We also anticipate that, during the course of its work, CoRWM will have acquired views relevant to subsequent stages of the policy programme. For example, the assessment of options will not consider potential radioactive waste sites; but it will raise siting issues including whether local communities should have a veto or be encouraged to volunteer, and whether they should be offered incentives. CoRWM will need to consider these issues, and may want to make recommendations to Ministers on them.

Formulation and agreement of work programme

16. CoRWM will prepare a detailed draft work programme, within this outline framework, that will enable it to deliver its recommendation to Ministers within the required timescales. The programme will include any proposed sub-groups or other activities or events that are likely to involve significant time and effort by the Committee. CoRWM will send this draft work programme to its sponsoring Ministers for discussion and agreement at an appropriate early stage of its work. Such discussion may lead to appropriate adjustment and refinement. In considering this programme, CoRWM and sponsoring departments and Ministers will be able to take account of the parallel work with Government in this area.

17. In familiarising itself with the relevant background and issues, CoRWM will make itself aware of the UK Radioactive Waste Inventory and the nature of current and expected future UK holdings of plutonium, uranium and spent nuclear fuel. It will take account of existing technical assessments and research into radioactive waste management, and reports arising out of the Defra and devolved administrations' public consultation on radioactive waste. It will work closely with Nirex and other organisations with relevant experience and expertise. CoRWM is also recommended to meet and take presentations from appropriate key-player organisations and to visit a selection of key UK and, possibly, other European nuclear sites. It will also take account of other relevant policy developments, including the UK energy review. In particular, it is recognised that CoRWM will need to engage with the Nuclear Decommissioning Authority (NDA) and it's predecessor, the Liabilities Management Unit, given that the former's output will directly impinge on the long-term responsibilities of the NDA.

18. CoRWM is recommended to aim to complete its first phase (familiarisation work and proposals for the waste inventory, the waste management options, and the criteria to be used in their assessment) after about a year from the date of its

appointment. It is thereafter recommended to aim for completion and reporting of the assessment work itself (the second phase) after about a further year. Provision of recommendations to sponsoring Ministers would follow as soon as possible after that.

19. CoRWM should indicate the timing proposed for its work in the draft work programme sent for discussion with sponsoring Ministers. The intent is that CoRWM's recommendations should be delivered around the end of 2005. If the Chair anticipates that CoRWM will be late in completing any current phase or overall delivery of its work programme, he or she should inform the sponsoring Ministers as soon as possible, together with an indication of whether and how the Committee can catch up during any subsequent phases of its programme. CoRWM will agree with Ministers how to proceed so as to be able to carry its programme forward.

Public engagement

20. CoRWM must inspire public confidence in the way in which it works, in order to secure such confidence in its eventual recommendations. Hence, its work should be characterised by:

- a transparency policy;
- an active programme of public and relevant stakeholder group debate, using innovative and appropriate techniques to ensure public involvement and support;
- encouraging people to ask questions or make their views known, listening to their concerns, ensuring that they are addressed and that people get a response;
- public meetings and other consultative processes, well advertised in advance and involving a variety of interested stakeholders including members of the public;
- holding a significant number of its own meetings in public;
- clear communications including the use of plain English;
- making information accessible to as many people as possible, including use of the internet, as well as ways of reaching people who do not use the internet; and
- providing opportunities for people to challenge information, for example by giving them access to alternative sources of information and points of view.
- Chair

21. The Chair will be responsible for supervising the work of CoRWM and ensuring that its objectives are achieved. He or she will be the main point of contact with the public and the media, in presenting progress and answering questions. The Chair will meet Ministers on appointment, and then six-monthly to report progress. Notes of these meetings will be published. The Chair will provide an annual written report to Ministers, by 1 December, which he/she may be required to present to Parliament or Assembly representatives as appropriate. The report will set out, among other things, CoRWM's work programme, progress made, and costs incurred. Ministers will also appoint a Deputy Chair who can assist the Chair as the latter sees fit.

Members

22. Members will work, under the Chair's supervision, to the programme agreed with sponsoring Ministers so as to ensure its satisfactory delivery. Members will have a collective responsibility to ensure achievement of CoRWM's overall mission. It is

not envisaged that Committee Members themselves will be responsible for day-to-day work activities but rather in deciding what these should be, overseeing their delivery, and reviewing and being responsible for the reports and other output delivered under CoRWM's name. Individual Members may be appointed by the Chair to undertake specific, active roles, for example chairing sub-groups or in representing CoRWM in meetings with the public, organisations who are contributing to the work, or the media. All Members will be subject to individual performance appraisal as laid down by the Cabinet Office guide (see next paragraph).

Standards

23. CoRWM is set up by, and answerable to Ministers and is funded by the taxpayer. It must therefore comply with the Cabinet Office guide "Non-Departmental Public Bodies a Guide for Departments".

24. These and other relevant procedural requirements, including working to standards laid down by the Office of the Commissioner for Public Appointments, are set out in the Code of practice for members of the Committee on Radioactive Waste Management to which Members will agree prior to appointment.

Resources

25. Sponsoring Ministers will provide CoRWM with resources both staff and financial to enable it to carry out its agreed programme of work. These will include a secretariat which will help CoRWM carry out its programme including, at the outset, providing reading material and arranging for further briefings and visits. The Chair and Members will have a collective responsibility for delivering the work programme within the agreed budget, although the Chair may request sponsoring Ministers for adjustment to this budget should this be considered necessary.

Payments

26. The Chair and Members will be paid for their work for CoRWM. They will also be fully reimbursed for all reasonable travel and subsistence costs incurred during the course of their work.

Annex 2 CoRWM members and working groups

Chair

Professor Gordon MacKerron
Economist Director Sussex Energy Group, SPRU (Science & Technology Policy Research) University of Sussex.

Deputy Chair

Dr Wynne Davies
Former Vice President, Group Health, Safety and Environment, Amersham plc and former Lecturer in Physics and Radiation Biology, University of London

Mary Allan
Lecturer, The North Highland College.

Fred Barker
Consultant, specialising in nuclear policy analysis and stakeholder engagement.

Professor Andrew Blowers OBE
Professor of Social Sciences at the Open University, former county councillor, former Board Member of Nirex UK.

Professor Brian D Clark MBE
Professor of Environmental Management & Planning and Board Member, Scottish Environment Protection Agency.

Dr Mark Dutton
Physicist and radiological protection and radioactive waste management expert, independent consultant, formerly with NNC.

Jenny Watson
Chair, Equal Opportunities Commission and former Chair, Nirex Independent Transparency Review Panel.

Fiona Walthall OBE
Former Colonel, British Army and former Chief Executive, Sargent Cancer Care for Children.

Professor Lynda Warren
Zoologist and Emeritus Professor of Environmental Law at the University of Wales Aberystwyth, Board Member of the Environment Agency.

Pete Wilkinson
Director of Wilkinson Environmental Consultancy, former Chair of Greenpeace UK, Director of Greenpeace International and co-founder of Friends of the Earth.

Note: Dr Keith Baverstock was dismissed and Professor David Ball resigned from CoRWM in April and May 2005 respectively.

Working groups

CoRWM members often work individually and in small working groups. These develop specific issues and projects, and make recommendations for consideration and decision-making in the main plenary meetings. More details are on our website (www.corwm.org).

The main groups operating over CoRWM's programme have been:

Comparing Options Group
This group managed the initial work to identify the long list of options, and the process of producing a shortlist, including production of the technical briefing papers which supported the shortlisting process.

Implementation Working Group
This group ensured that CoRWM gave appropriate advice on how its recommendations could be implemented. This included advice on developing a siting process including partnership with local communities.

Information Working Group
This group managed the process of providing the technical input into the detailed assessment of CoRWM's short-listed options, including the scoring, by specialist panels of each option against CoRWM's criteria. Among other things, the group oversaw the collection of information requested by the specialists to enable them to carry out this work.

Integration Working Group
This group integrated CoRWM's work programme, including its MCDA, the holistic options assessment, work on implementation issues and the development of the final report to Government.

Inventory Working Group
This group managed the process by which CoRWM produced its inventory report, including the commissioning and review of technical work following discussions with the waste producers and other stakeholders.

Phase 3 Working Group
This group developed the detailed process for assessing the shortlisted options. This included developing the MCDA and the holistic assessment processes, and how these would be implemented.

Principles Working Group
This group formulated the key guiding principles under which CoRWM has worked, advised on decision-making processes that reflected these principles, and led the Committee's deliberations on ethical and environmental aspects of radioactive waste.

Public and Stakeholder Engagement Working Group
This group set the overall PSE strategy, and managed the implementation of each of the public and stakeholder engagement programmes.

Quality Assurance Group
This group ensured that CoRWM's work was of good quality and that it led to robust recommendations to Government.

Annex 3 Inventory

The following text is taken from CoRWM Document No. 1280 (CoRWM's Radioactive Waste and Materials Inventory – July 2005: A Summary)

Radioactive Wastes & Materials

Radioactive wastes have been produced in the UK since the 1940s, mainly from developing and using nuclear power to generate electricity, but also from the nuclear weapons and nuclear-powered submarine programmes, and from the use of radioactive materials in industry and medicine.

Radioactive wastes are hazardous to people and the environment, and many wastes will continue to be hazardous for thousands of years and some will remain hazardous for hundreds of thousands of years.

CoRWM has been asked to look at the higher activity wastes:

- High Level Waste
- ILW
- Low Level Waste (unsuitable for the UK disposal facility at Drigg in Cumbria).

High Level Wastes (HLW)

Wastes in which the temperature may rise significantly as a result of their radioactivity, so this factor has to be taken into account in the design of storage or disposal facilities.

HLW comprises the waste products from reprocessing spent nuclear fuels. These waste products arise in the form of highly radioactive nitric acid solutions, which are being converted into borosilicate glass within stainless steel canisters, using a process called vitrification.

Intermediate Level Wastes (ILW)

Wastes exceeding the upper boundaries for LLW, but which do not need heat to be taken into account in the design of storage or disposal facilities.

The major components of ILW are metal items such as nuclear fuel casing and nuclear reactor components, moderator graphite from reactor cores, and sludges from the treatment of radioactive effluents.

Non-heat generating waste is stored in tanks, vaults and drums. In time it will be retrieved, and packaged as ILW by immobilising the wastes in cement-based materials within stainless steel drums, or for large items in higher capacity steel or concrete boxes.

Low Level Wastes (LLW)

Wastes other than those suitable for disposal with ordinary refuse but not exceeding specified levels of radioactivity.

Most LLW can be sent for disposal at the Drigg facility. LLW unsuitable for disposal is mostly reflector and shield graphite from reactor cores, which contains concentrations of carbon-14 radioactivity above those acceptable at Drigg.

There are already over 80,000 cubic metres (over 100,000 tonnes) of higher activity radioactive wastes awaiting a decision on how they should be managed for the long-term. This quantity will increase substantially as the programme of decommissioning (dismantling and demolition) nuclear power reactors and other nuclear facilities develops over the coming decades.

Much larger volumes of lower activity wastes are forecast – this is the subject of a separate Government review.

CoRWM has also to consider the implications for waste management should some or all of UK accumulations of radioactive materials be declared surplus to requirements and so classified as wastes. These materials are:

- Plutonium
- Uranium
- Spent nuclear fuel.

Plutonium

A radioactive element created as a by-product in nuclear reactors. It can be separated from nuclear fuel by reprocessing. Separated plutonium can be used as a nuclear fuel and in nuclear weapons.

Separated plutonium is stored as an oxide powder.

Uranium

A radioactive element that occurs in nature. Uranium can be used for nuclear fuel and in nuclear weapons. It is also a by-product of spent fuel reprocessing. Less radioactive uranium (called depleted uranium) has more commonplace uses, such as counterweights in aircraft.

Most uranium is stored either as gaseous uranium hexafluoride or as an oxide powder.

Spent nuclear fuel

Nuclear fuel that has been irradiated in a nuclear reactor. It can be reprocessed (to separate out plutonium and “unburnt” uranium) or managed in some other way.

Like HLW, spent nuclear fuel is intensely radioactive and generates heat. It is usually comprised of uranium oxide, and contains the waste species (fission products) of irradiation.

July 2005 Inventory Update

We use the term "inventory" to describe the types and amounts of radioactive wastes and materials that the UK has to manage.

In October 2004 we issued our preliminary report on the inventory for consultation during the first stage of public and stakeholder engagement. We received much constructive feedback that identified a number of headline issues on the inventory where we have undertaken further investigations and analysis. In particular we have included:

- Data on radioactivity
- Data on the most important radionuclides in the context of long-term safety

- Data on the heat generation rates of alternative strategies and their potential impact on the short-list of options
- ILW that might be suitable for near surface disposal, either with or without treatment
- Spent sealed radioactive sources (SSRSs)
- Alternatives to our nuclear power reactor new build scenario.

Furthermore, we have taken the opportunity to update the inventory where more recent information is available. In particular we have made use of information in the draft 2004 UK Radioactive Waste Inventory (RWI) being prepared by Defra and Nirex that was not available when we prepared our preliminary report. This information is subject to change.

Baseline Inventory

We have established a baseline inventory of radioactive wastes and materials on which CoRWM will make its recommendations on the long-term waste management options.

The baseline inventory is based on the following principal assumptions:

Nuclear power reactors

- All operating Magnox reactors are shut down by 2010
- AGRs operate for up to 35 years, with the last shutdown in 2023
- Sizewell B PWR operates for 40 years and is shutdown in 2035
- No new nuclear power reactors are constructed.

Spent fuel reprocessed

- All Magnox fuel (55,000tU)
- AGR fuel covered by existing contracts (5,000tU)
- Overseas LWR fuel covered by existing contracts (4,500tU)
- Return of overseas Pu, U and HLW, with ILW & LLW substitution.

Radioactive materials to be managed as wastes

- All UK stockpile of separated plutonium (102 tonnes)
- All UK stockpile of uranium (153,000 tonnes)
- AGR fuel not covered by existing reprocessing contracts (3,500tU)
- Sizewell B PWR fuel (1,200tU).

All radioactive wastes, including spent fuel, are packaged so that they are in a form suitable for long-term management.

The volume and radioactivity of the wastes are:

Type	Packaged volume (cubic metres)	Radioactivity (terabecquerels)
HLW	1,290	39,000,000
ILW	353,000	2,400,000
LLW (non-Drigg)	37,200	<100
Plutonium	3,270	4,000,000
Uranium	74,950	3,000
Spent nuclear fuel	8,150	33,000,000
Total	**477,860**	**78,000,000**

Uncertainties in the Baseline Inventory

We have examined a number of factors in order to determine how changes in the assumptions used to construct the baseline inventory might affect the types and quantities of radioactive waste. These factors are:

- The building of new nuclear power reactors
- The quantity of spent fuel reprocessed
- ILW and LLW substitution (return additional HLW in place of ILW from reprocessing overseas spent fuel)
- Lifetimes of existing nuclear power reactors
- Decay storage and decontamination of ILW (for disposal as LLW)
- Early decommissioning of nuclear power reactors
- Waste segregation (of short-lived ILW; of mixed ILW/LLW streams)
- Quantity of unaccounted spent sealed radiation sources (SSRSs)

Their potential impact on the packaged volumes of radioactive waste and materials are given below.

In determining the impact of new nuclear power reactors we have assumed a programme of ten AP1000 reactors of Westinghouse design, which would be sufficient to maintain current nuclear generating capacity as today's reactors shut down. Our assumption is that the spent nuclear fuel would not be reprocessed. It is anticipated that other potential water-cooled reactor alternatives such as the European Pressurised Water Reactor (Framatome ANP design) or the Advanced Boiling Water Reactor (an evolution of the General Electric BWR design) would give rise to similar quantities of spent fuel and radioactive wastes. The Pebble Bed Modular Reactor is an alternative reactor concept that would give rise to different wastes, but given its development and licensing status, it is less likely to be the reactor selected for new UK nuclear power reactors.

Should there be a decision to close Magnox reprocessing earlier than forecast, we have assumed that the Magnox power reactors would be shut down and the remaining spent fuel would be reprocessed.

In addition the factors listed above, volume estimates are based on assumptions as to how waste will be packaged in the future for long-term management. For certain types of wastes there are uncertainties in the nature of the packaging process that will be adopted, the degree of volume change and the type of container used. All these can affect the packaged volume, although the quantity of radioactivity will remain unchanged.

High Level Waste (HLW) – 1,290 cubic metres

Potential for increase in volume (cubic metres)

+ 250	Reprocess remaining 3,500tU AGR spent fuel
+ 90	Reprocess 1,200tU Sizewell B PWR spent fuel
+ 60	No substitution for overseas wastes

Potential for decrease in volume (cubic metres)

Up to - 160	Early closure of Magnox reprocessing / Magnox reactors
Up to - 250	Early closure of Thermal Oxide Reprocessing Plant (THORP)

Should there be new nuclear power reactors built, we have taken the view that spent fuel is much more likely to be packaged directly than reprocessed.

Heat from the radioactive decay of HLW decreases significantly with time.

Intermediate Level Waste (ILW) – 353,000 cubic metres

Potential for increase in volume (cubic metres)

+ 7,000	Reprocess remaining 3,500tU AGR spent fuel
+ 2,000	Reprocess 1,200tU Sizewell B PWR spent fuel
+ 4,100	Extend AGR lifetimes by 5 years (fuel not reprocessed)
+ 170	Extend Sizewell B PWR lifetime by 10 years (fuel not reprocessed)
+ 17,580	Early decommissioning of nuclear power reactors
+ <10	Unaccounted SSRSs
+ 9,000	New build programme of 10 AP1000 reactors

Potential for decrease in volume (cubic metres)

Up to – 8,800	Early closure of Magnox reprocessing / Magnox reactors
- 5,000	Return of ILW from reprocessing overseas fuel (no substitution)
- 19,000	Decay storage / decontamination (waste producer plans)

- 4,500	Segregation of ILW and LLW in cases where they are mixed and disposal of LLW

Low Level Waste (ILW) – 37,200 cubic metres

The nature of the most of the waste - activated reactor core graphite – would make it difficult to treat in order that it would be acceptable for disposal to Drigg. There may be some uncertainty in the relative quantities of ILW and LLW reactor graphite, but this will not affect the inventory.

Plutonium – 3,270 cubic metres

Potential for increase in volume (cubic metres)

+ 580	Reprocess remaining 3,500tU AGR spent fuel (18 tonnes Pu)
+ 450	Reprocess 1,200tU Sizewell B PWR spent fuel (14 tonnes Pu)

Potential for decrease in volume (cubic metres)

Up to – 640	Early closure of Magnox reprocessing / Magnox reactors (up to 20 tonnes Pu)
Up to - 580	Early closure of THORP (up to 18 tonnes Pu)
Up to - 3,270	Use of UK separated plutonium in MOX fuel for new build programme of nuclear reactors (up to 105 tonnes Pu)

British Energy has advised us that separated plutonium could in principle be used in the manufacture of mixed oxide fuel (MOX) for Sizewell B and AGRs, although the commercial case (mainly in terms of the higher cost of the fuel, and the cost of plant modifications particularly in the case of the AGRs) makes it unattractive. New nuclear power reactors, depending on design, could also use MOX fuel, but at today's uranium prices, burning MOX fuel in light water reactors would be uneconomic. Thus existing stocks of separated plutonium would only be used if uranium prices rose, MOX fuel were used as a plutonium management tool, or the fast reactor programme was resumed.

About 5% of existing separated plutonium stocks are likely to require extensive chemical treatment to allow it to be used as fuel.

Uranium – 74,950 cubic metres

Potential for increase in volume (cubic metres)

+ 1,660	Reprocess remaining 3,500tU AGR spent fuel (3,390 tonnes U)
+ 550	Reprocess 1,200tU Sizewell B PWR spent fuel (1,120 tonnes U)

Potential for decrease in volume (cubic metres)

Up to – 3,390	Early closure of Magnox reprocessing / Magnox reactors (up to 6,940 tonnes U)
Up to - 1,660	Early closure of THORP (up to 3,390 tonnes U)

Up to – 6,840	Use of UK uranium in fuel for new build programme of nuclear reactors (up to 14,000 tonnes U)

Spent fuel – 8,150 cubic metres

Potential for increase in volume (cubic metres)

+ 840	Extend AGR lifetimes by 5 years (extra 1,320tU fuel not reprocessed)
+ 680	Extend Sizewell B PWR lifetime to 50 years (extra 300tU fuel not reprocessed)
+ 31,900	New build programme of 10 AP1000 reactors (14,000tHM)

Potential for decrease in volume (cubic metres)

- 5,410	Reprocess remaining 3,500tU AGR spent fuel
- 2,740	Reprocess 1,200tU Sizewell B PWR spent fuel

Heat from the radioactive decay of spent fuel decreases significantly with time.

CoRWM has developed four alternative scenarios to that which underpins the baseline inventory, in order to illustrate how the various uncertainties identified above could affect the total packaged volume.

Scenario	Packaged volume (cubic metres)
Baseline inventory	477,860
1: No substitution of ILW	472,920
2: Decontamination, decay storage and segregation of ILW	454,360
3: AGR and PWR life extensions plus programme of 10 new AP1000 PWRs	514,440
4: Early closure of reprocessing and early power reactor decommissioning	483,490

Conclusions

CoRWM has updated the inventory of radioactive wastes and materials on which it will make its recommendations on the long-term management options. The July 2005 inventory has taken into account the feedback we have received from the first stage of public and stakeholder engagement. It also includes the latest information from the 2004 UK Radioactive Waste Inventory (draft status).

We have determined the baseline inventory for the three categories of radioactive wastes - HLW, ILW and non-Drigg LLW – and three categories of radioactive materials - plutonium, uranium and spent nuclear fuel - that fall within our remit. The total packaged volume is 477,860 cubic metres and the total radioactivity is about 78,000,000 terabecquerels.

ILW makes up about 74% of the baseline inventory volume, uranium about 16% and the other categories in total about 10%. HLW makes up about 50% of the radioactivity, spent fuel about 42% and the other categories in total about 8%.

We have quantified uncertainties in the baseline inventory volume by examining how changes in our assumptions might affect the types and quantities of wastes and materials. To illustrate these uncertainties we have proposed four example scenarios.

These scenarios demonstrate that the extent to which the baseline inventory volume is likely to vary in the light of reasonably foreseeable developments in nuclear energy and waste practices is relatively small, of the order of less than 10%.

The only scenario that would change the baseline inventory radioactivity to any significant extent is that where there is a commitment to future nuclear energy with life extensions to existing AGR and PWR stations and a programme of new reactors. In this scenario the amount of radioactivity (and the quantity of spent fuel for long term management) could be up to a factor of five greater than the baseline.

Should ILW substitution not be implemented, the impact on the baseline inventory volume and radioactivity would be very minor.

Similarly early closure of spent fuel reprocessing with early reactor decommissioning would have a minor impact on the baseline inventory volume and radioactivity.

We have determined that only a small proportion of ILW (about 1%) can be categorised as short-lived and so potentially suitable for near surface disposal. Furthermore we have concluded that the impact of waste segregation in order that wastes can be routed for near surface disposal, further to that which is planned, would likely be very modest.

Further information on the inventory can be found in CoRWM Document No. 1279.

Annex 4 Additional detail on options assessment

The outcome of CoRWM's options assessment process, including the views of specialists on the options, is set out in the main body of this report. This annex provides greater detail on particular aspects of the process, including the way it was designed and constituted:

Section 1 The way in which CoRWM selected its options assessment method.
Section 2 The formulation of the "value tree".
Section 3 The selection of seven materials/wastes for assessment.
Section 4 The process of specialist scoring of options.
Section 5 Acquiring the inputs for sensitivity testing.
Section 6 Non-geological disposal of reactor decommissioning waste, in particular, CoRWM's definition of that waste stream.

Section 1 Assessing the method for assessing the options

1.1 During the initial information gathering and trialling period, CoRWM looked at "Deliberative Mapping", a "participatory, multi-criteria, option appraisal process developed by researchers working at University College London and the University of Sussex based on 10 years of experimentation"[1]. Deliberative Mapping is designed to bring citizens, stakeholders and specialists together in an analytical and deliberative process that supports the application of criteria in a systematic appraisal of options. It also provides opportunities for deliberation between citizens and specialists. CoRWM was attracted by the potential for involving these groups and ran a trial process[1] to assess the contribution this methodology could make to its appraisal of options.

1.2 The core appraisal process of Deliberative Mapping is based on two decision-support tools:

- *multi-criteria mapping*, a primarily quantitative methodology with its own dedicated software which allows specialists and stakeholders to undertake a facilitated option appraisal process in two to three hours.

- *stakeholder decision analysis*, a group-based methodology designed to frame problems, scope options, elicit criteria and make judgements through facilitated deliberation developed for environmental decision making with stakeholders and citizens.

1.3 Although the Committee decided not to adopt Deliberative Mapping in total, many lessons were learned about how to work with specialists, stakeholders and the public, and several techniques used in the Deliberative Mapping trial were later used in CoRWM's bespoke assessment process. A review of alternative methods for engaging with the public and stakeholders[2] was also used in the design of the process.

1.4 CoRWM formed the Phase 3 Working Group in October 2004 to make recommendations to the whole Committee on how option assessment should be carried out. Work was commissioned from IDM, a decision-making consultancy. The IDM review[3] examined methodologies including Multi-Criteria Decision Analysis (MCDA), Strategic Action Planning, Joint Fact Finding, and the part these have played in decision-making, especially in radioactive waste management. In response to the difficulties posed by decision-making in the area of radioactive waste management (complexity; disputed and uncertain evidence; multi-dimensionality) it concluded that MCDA was particularly suitable for encompassing and dealing with these issues.

1.5 This was on the basis that:

- it is open and explicit;
- the choice of objectives and criteria that any decision-making group may make are open to analysis and change if they are felt to be inappropriate;
- scores and weights, when used, are also explicit and are developed according to established techniques. They can be cross-referenced to other sources of information on relative values and amended if necessary;
- performance measurement can be sub-contracted to experts so need not necessarily be left in the hands of the decision-making body itself;
- it can provide an important means of communication within the decision-making body itself and between that body and the wider community;
- scores and weights can be used that provide an auditable trail and can be changed if new or updated information becomes available.

1.6 The IDM report was peer reviewed by Tim McDaniels, of the Eco-Risk Research Unit at the University of British Columbia[4]. In a supplementary note to this report Professor McDaniels indicated that “the only method I know of to address these features of such decision problems in a responsible manner is multiple objective (otherwise known as multi-criteria or multi-attribute) decision analysis”.

1.7 CoRWM held an option assessment methodology workshop at its plenary meeting in Southampton on 15 December 2004 at which Professor Gregg Butler (Manchester University and IDM) and Professor Ortwin Renn (Stuttgart University and DIALOGIK gGmbH) gave presentations. For this meeting, advice was sought from Professor Renn on a suitable decision analysis methodology for CoRWM to use in option appraisal. Professor Renn's Cooperative Discourse Methodology was summarised in CoRWM document 844.[5] The resulting decision to adopt a version of MCDA is reported in the minutes of the December 2004 CoRWM plenary meeting.[6]

1.8 Professor Renn and Professor Larry Phillips (London School of Economics Decision Analysis Unit) were co-opted onto the Phase 3 working group, along with Richard Harris, a specialist in stakeholder engagement, to help design a bespoke assessment process. CoRWM document 898[7], presented to the January 2005 plenary meeting, contained outline proposals to be put out to consultation during CoRWM's second round of public engagement from 4 April to 27 June 2005.

1.9 Among other things, the proposals envisaged:

- researching the various scoring methods used in MCDA;
- use of specialists to score the options;
- review of scoring by stakeholders;
- weighting of criteria by stakeholders and members of the public to reflect their relative importance;
- a parallel "holistic" process of assessing the options (using intuitive judgment of the options as a whole).

1.10 Thus, the structure of a formal MCDA would be used "to provide an essential element of a wider assessment of the short-listed options. The process is based on key principles from Ortwin Renn's Cooperative Discourse Model, in which different groups complete appropriate parts of the process, and there is a balance between a MCDA type approach and a more holistic assessment of options"[8].

1.11 The methodology for the holistic assessment was developed later in the programme and was based on assessing the options as a whole rather than breaking them down into their specific attributes. CoRWM's Integration Group planned a series of plenary discussions and panels to discuss particular aspects in more depth. The topics chosen were those that would either self evidently play a critical role in assessing the options, such as the long term safety of geological disposal, or those that had been highlighted during PSE and/or the MCDA as being complex or disputed, and important discriminators, such as retrievability/flexibility.

1.12 The process for the holistic assessment was planned by a small group of members with the help of Richard Harris. The proposed method was discussed in plenary meetings and was modified to ensure that all members were satisfied that it would allow them to bring in to discussions all the aspects that were important to them. It included a combination of further in-depth discussions on critical issues, and a method of recording members' initial option preferences for each waste stream to stimulate debate on the areas of consensus and disagreement. This was the first moment that members declared their provisional option preferences, and was an important step in moving towards the formation of a draft strategy for all waste streams.

Section 2 The "value tree"

2.1 The options assessment criteria, together with their "implicit goals", and a set of factors whereby option performance can be assessed, are set out in a document known as the "CoRWM value tree". The value tree concept is used to elicit and represent the concerns and evaluative criteria used for judging different options on the part of all relevant stakeholder groups. According to Ortwin Renn, the process results in "a list of hierarchically structured values that represent the concerns of all affected parties"[8]. Thus, there are headline criteria which have associated sub-criteria at the next level of detail, but the headline criteria themselves are not arranged hierarchically.

2.2 The first draft of the value tree (December 2004) drew on a mix of published material including:

- existing published material: Radioactive Waste Management Advisory Committee[9], Nirex[10], COMPAS,[11] AkEND,[12] NEA;[13]
- work commissioned by CoRWM, e.g., on the Deliberative Mapping trial and ethical and environmental principles;[14;]
- the values incorporated in the screening criteria, as well as some outputs from the first round of PSE that had not been incorporated into them[15];
- member input.

2.3 An important stage of development occurred with preparation of the Consultation Document for the second round of public and stakeholder engagement and comments made during the engagement period itself.[16] The responses were discussed at the July 2005 plenary meeting of CoRWM and the outcome recorded in the minutes of that meeting.[17]

2.4 Document 1202.2[18] indicated the process by which outputs from the second round of engagement would be taken account of in the further development of the value tree. This led to its deployment as a key tool in the MCDA specialist-led scoring in December 2005. Thus, both public and stakeholder engagement outputs and the views of the specialists influenced the composition of the value tree.

2.5 The final version of the value tree (November 2005) was developed by CoRWM drawing on the views of specialists (see below) and the concerns of the public and stakeholders. The views and concerns are arranged under an initial set of broad headings that, at lower levels, are broken down into more specific issues. There are 11 "headline criteria" and 27 sub-criteria; each of the sub-criteria is provided with a descriptor ("Extent to which the option is expected to .. ..") and with the factors relevant to assessing the performance of each option against it. The need for a manageable process meant that the options would be formerly assessed (scored) at the sub-criterion level. A "scoring scheme" (see Section 4) was formulated for each sub-criterion to reflect the terms of its descriptor and the associated factors.

Section 3 The materials and wastes for assessment

3.1 The assessment of the options was carried out for each waste stream. Seven types of materials and wastes were scored by the specialists, each of which had unique characteristics that meant it merited separate assessment. The seven materials and waste were:

- High level waste
- Spent nuclear fuel
- Plutonium
- Highly enriched uranium
- Intermediate level waste and low level waste not suitable for the LLWR
- Depleted, natural and low enriched uranium
- Reactor decommissioning waste.

3.2 The reasons for considering these waste streams separately were as follows:

- High level waste and spent fuel produce enough heat for them to require cooling during the initial years of storage and their heat production is a factor that has to be taken into account when designing a disposal facility.
- Plutonium and highly enriched uranium can be used to produce nuclear weapons as well as being potential reactor fuels and therefore have different security implications compared with high level waste and intermediate level waste.
- Spent nuclear fuel also contains plutonium and is potentially desirable to terrorists.

- Intermediate level waste is much more chemically complex than the other waste streams. This has implications for the disposal concept, for example, the type of backfill required to achieve the desired level of alkalinity in groundwater entering the repository and the potential for gas generation from the degradation of the waste.

- Depleted, natural and low-enriched uranium is a potential source of energy, but its radioactivity is similar to some naturally occurring rocks so that its potential hazard is less than that for the other streams.

- There are more options available for the disposal of reactor decommissioning waste than there are for the disposal of the other waste streams, which allows the transport of these wastes to be minimised.

3.3 The two types of uranium were treated as one during the latter stages of option assessment on the basis that if uranium came to be managed as waste, its highly enriched form would be physically brought within a matrix of less active uranium.

Section 4 The specialist scoring process

4.1 The way in which CoRWM selected specialists to participate in the scoring of options, and the organisation of them into workshops, has been described in Chapter 11. The objectives of the first stage of the workshops (June and July 2005) were to review the definition of the sub-criteria and to define the scoring schemes for each sub-criterion, identifying the information needed to allow scoring to be carried out.

4.2 In essence, the scoring schemes provide a means for converting a judgement on the extent to which an option meets the implied goals of each sub-criterion (how well it performs in each case) into a numeric score on a fixed scale of 1-9 (the former score representing the least preferred and the latter representing the most preferred). In order that CoRWM's recommendations are transparent and auditable, the reasons for the scores given by the specialists needed to be comprehensively and accurately recorded.

4.3 Seven workshops were held: safety; security; environment; implementability (including flexibility); social and economic (including amenity); burden on future generations; and cost. The output required from the workshops was a scoring scheme for each sub-criterion with its rationale, and the identification of further information required in order for scoring to be done later in 2005.

4.4 The workshops were facilitated by Catalyze Ltd by means of "Decision Conferencing" techniques supported by the MCDA approach and using the Catalyze software tools - Hiview and M-MACBETH (see the glossary for a description of these assessment tools.) Briefing information for specialists was provided in the form of a series of criteria-specific Background Papers. A total of 69 specialists were involved, most of whom also participated in later workshops.

4.5 The outcome of the June and July workshops was reported by Catalyze.[19] The majority of the scoring schemes were completed by the specialists but the Safety and Security workshops were reconvened in September 2005 to complete their work.[20]

4.6 As a result of the workshops it was agreed that:

- proximity would be dealt with through discussion on intra-generational equity outside the formal MCDA;
- the blight sub-criterion was dropped because it was considered to be too site specific to be scored.

4.7 A trial run was held in August 2006 to ensure that:

- each of the CoRWM short-listed management options could be scored against each of the sub-criteria;
- the criteria were preference independent (i.e., that scores on one criterion do not need to be consulted when scoring the options against any other criterion);
- "double counting" did not exist among the criteria (although some factors may appear under more than one sub-criterion);
- the criteria set was complete.

4.8 The trial involved a panel of CoRWM members and members of the Defra Chief Scientific Advisor's expert panel on CoRWM's work. The report of the trial[21] was a product of CoRWM consideration as well as that of Catalyze. As a result of the trial, the specialists were asked to score the interim storage options without any assumption about the management route that would follow. Any impact passed on into the post-300 year period would be captured under the "Burden on Future Generations" criterion.

4.9 The final version of the value tree was developed by CoRWM's Information working group, with regular report-back to the plenary Committee. This process can be traced by reading the minutes of the September and November 2005 plenary meetings, and the supporting documents for those meetings[22].

4.10 The 14 option variants were scored against the 27 sub-criteria at scoring workshops held in December.[23]

4.11 The environment workshop was reconvened on 11 January 2006 in order to score the radiological impact of the options on the environment over the short-term (0-300 years) and separately in the long term (over 300 years).

Section 5 Acquiring the inputs for sensitivity testing

5.1 CoRWM used the scores derived by the specialists as the baseline case in the MCDA but also invited comments on the scores from as wide a circle of interested parties as possible. These views were considered by CoRWM when deciding what sensitivity testing to do using the MCDA model. Sensitivity testing allows the impact of variations from baseline case scores to be explored, thereby increasing understanding of how the options perform from various perspectives.

5.2 Opportunities to comment on the scores derived from two sets of sources:

- the CoRWM National Stakeholder Forum and participants in the Nuclear Site Round Tables were given opportunity to make preliminary comments on the scores during the third round of public and stakeholder engagement in January and February 2006 and were encouraged to submit more detailed comments via the website;

- written and website comments on the report of the scoring workshops. Documents on which comments were invited were posted on the website with a series of questions developed and agreed by CoRWM. In addition, the CoRWM Chair and members of CoRWM's Quality Assurance group contacted several of the scientific learned societies to ask for their comments.

5.3 A paper summarising the impact of these comments on the scoring outcome[24] was submitted to the CoRWM MCDA decision-making meeting on 29-31 March 2006.[25]

5.4 CoRWM aspired to "frame its MCDA in the values and needs of society" and needed to be confident that these values were reflected in the weight (relative importance) attached to each criterion. The process of swing weighting ensured that judgements could be made on the basis of the relative importance of the criteria taking account of the difference (or "swing") between the top and bottom of the scoring scales. Thus safety, for example, was not judged purely on whether it was considered to be important per se, but posed the question of how important was the difference between a score of 1 and a score of 9. Swing weighting was carried out at the sub-criterion level.

5.5 Processes to inform criteria weighting were undertaken in five types of activity as part of the third phase of public and stakeholder engagement. These were:

Activity	Weighting process	Level of weighting	Participants
1.Discussion Guide	Groups asked to identify 4 most important criteria, and 2 least important criteria	Headline criteria	568 self-organising groups from across the UK, including community groups, environmental groups, older people and schools
2. Schools Project	Ranking of criteria following research and discussion	Headline criteria	1,305 students (age range 11-18) from 15 schools in Bedfordshire
3. Citizens' Panels	Judgements of (a) best and worst performing options against each criteria and (b) importance of that difference in performance against each criterion	Headline criteria	Four panels of 12-16 recruited citizens of mixed gender, age and social class, covering Scotland, Wales, North and South England
4. National Stakeholder Forum	Judgements of the importance of the difference in performance between best and worst options (based on specialist judgements of option performance)	Sub-criteria	One meeting of 20 stakeholders from national organisations and bodies. Weighting undertaken at ‘sector’ tables
5. Nuclear Site Stakeholder Round Tables	Judgements of the importance of the difference in performance between best and worst options (based on specialist judgements of option performance)	Sub-criteria	Eight Round Tables, with stakeholders from local organisations and bodies around nuclear sites, with between 17-26 participants at each event. Weighting undertaken at ‘sector’ tables at each event

5.6 A CoRWM report[26] collated the results from these activities for the purposes of helping CoRWM members carry out the swing weighting process at the Brighton plenary meeting in March 2006.

5.7 The meeting used sensitivity testing to test the robustness of the MCDA results by a process that employed different criteria weightings and scores to represent the views of various stakeholders and demographic sectors. The score and criteria weight variations from the processes described above were grouped into feedback from different sectors. Those sectors were NGOs, older and younger citizens, local government bodies and community organisations, non-departmental public bodies, the learned societies, and the environmental regulators. For each sector, all the feedback received on both scores and weights was analysed and the trends were identified. This enabled a sector 'position' to be articulated in terms of new suggested scores and weights. For example, the new scores and weights for the Green NGO perspective reflected their doubts about the efficacy of disposal to reduce burden and the flexibility offered by the Phased Geological Disposal option, and their belief that environment, amenity, implementability and flexibility should be more heavily weighted.

Section 6. Non-geological disposal of reactor decommissioning waste

6.1 The issues associated with this form of managing waste proved to be more complex than CoRWM anticipated and, for this reason, an outline of the thinking that led CoRWM to short-list the option is set out here.

6.2 As described in Chapter 10, feedback from public and stakeholder engagement suggested that there was support for local solutions for reactor decommissioning waste in order to avoid the transportation of these large volumes of waste. The Committee therefore expanded the option of the near-surface disposal of short-lived ILW to encompass suitable means of dealing with some longer-lived radio-elements contained in the waste from the decommissioning of nuclear reactors. A fuller explanation is contained in CoRWM document 1381[27] which, in turn, refers at length to the technical issues raised during the short-listing of options.

6.3 The options envisage, in different ways, the containment of wastes within man-made structures with additional barriers (such as sand, soil or clay) in place. They do not rely on the containment features provided by geological formations. It is extremely unlikely that safety cases could be made for the non-geological disposal of high-level waste, spent nuclear fuel, plutonium, uranium, or intermediate-level waste containing long-lived transuranic elements such as neptunium or americium.

6.4 The non-geological disposal variants are:

- Near surface engineered vaults excavated side-by-side and covered by earth/clay at or near current waste locations (option 10);
- Near surface engineered vaults similar to option 10 at a central location (option 11);
- Mounded over reactors; the reactor is defuelled and its high active components removed. All void spaces (including the pressure vessel and biological shield) would be filled with cement and the structure covered with sand, earth and clay (option 12);

- An engineered vault excavated at a depth of less than 100 metres at or near current waste locations and accessed by a tunnel (option 13);
- An engineered vault similar to option 13 at a central location (option 14).

6.5 The example for the design of options 10 and 11 is the LLWR and that for options 13 and 14 the facility at Forsmark in Sweden.

6.6 Document 1381 explains how CoRWM decided on the inventory of reactor decommissioning waste for assessment purposes. The inventory identified by CoRWM (with one member, Pete Wilkinson, expressing strong reservations) encompasses all reactor decommissioning waste (ILW and LLW unsuitable for the LLWR) of between 110,000 - 120,000 cubic metres, of which only about 2,000 cubic metres contains only radionuclides with a half-life of 30 years or less. Thus, the CoRWM reactor decommissioning waste inventory ("inventory c" in document 1381) contains very large volumes of graphite contaminated to varying degrees by Carbon-14 (half life of 5,730 years) depending on the location of the graphite in the reactor.

6.7 The reactor decommissioning waste can be physically segregated between "short-lived" and "long-lived", but, on the face of it, it would not be economic to dispose of the short-lived inventory of 2,000 cubic metres on a local basis, i.e., split between more than 20 local sites. The remainder has to be classified as "long-lived" although the presence of long-lived radionuclides varies.

6.8 Document 1381 said that CoRWM would not recommend any of the non-geological disposal options unless it was satisfied on the issue of the impact on public health and the environment of leaving long-lived wastes disposed of in situ for longer than 300 years.

6.9 The specialists were asked to score non-geological disposal on the basis of inventory c, but were unable to do so because, as the Catalyze report[23] pointed out:

"It was recognised that the non-geological disposal options would be implementable only if there was a measure of assurance that more active and (especially) longer-lived components of the reactor decommissioning waste had been segregated for management in the same way as other intermediate-level waste. For the purposes of the assessment, it would be assumed that such options had indeed been considered to be implementable on this basis."

6.10 Advice was also received from the Environment Agency that:

"... expressed concern about the possible disposal of significant quantities of long-lived radionuclides such as carbon-14 and chlorine-36 under non-geological disposal. Reactor graphite could be segregated and disposed of separately. For other dominantly short-lived wastes arising from reactor decommissioning, it might be possible to make a safety case for non-geological disposal, but this needs to be assessed quantitatively on the basis of the details of the proposed disposal inventory, including the component of long-lived activity that will be associated with such wastes. It was noted that the safety case for the disposal of long-lived radionuclides would vary from site to site, for example in relation to the potential for terrestrial versus marine discharge of radioactivity (with considerable differences in the extent of dilution that would be expected). It is also appropriate to highlight the issue of coastal erosion if disposal in the vicinity of a vulnerable coastline is under consideration. Thus, the Agency would not favour non-geological disposal for wastes with a significant long-lived component. Mounding was a particular problem (viewed with "disfavour") as it does not involve a purpose-built engineered facility. It might be hard to claim that this concept is an optimised disposal concept." [28]

6.11 On the basis of the EA and specialist views, CoRWM revised its definition of reactor decommissioning waste to encompass short-lived ILW and only those elements or amounts of longer-lived radionuclides that would not produce a significant hazard after 300 years.

6.12 At the same time, it is clear that a number of overseas countries that are decommissioning their reactors are considering the non-geological disposal option. For example, the French waste management organisation, ANDRA, is investigating a long-term waste management system for graphite wastes in a sub-surface disposal facility at a depth of approximately 15 metres in low-permeability clay or marl.

6.13 The nature of safety cases is such (for example, they are site-specific) that it would always have been impossible for CoRWM to indicate whether or not a case could be made for localised (or centralised) non-geological disposal of reactor decommissioning waste. In the event, CoRWM is also unable to answer the question that it set itself in document 1381[27] on the question of the environmental and health impact from non-geological disposal after 300 years. This question will turn on each of the site-specific safety cases if and when the site operators decide to try to make them.

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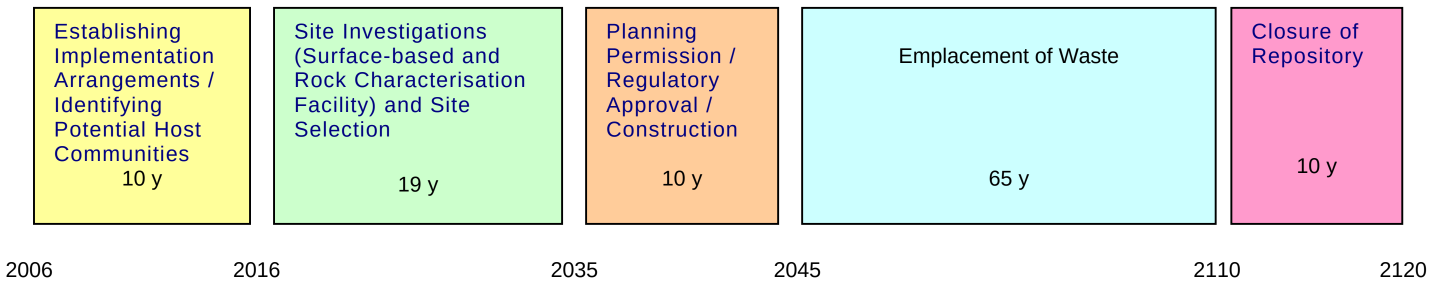
Annex 5 An indicative timeline

Introduction

1. A large proportion of the public and stakeholders that participated in CoRWM's engagement process asked the Committee to provide some indication of the timescale associated with implementing its recommendations.

2. CoRWM itself has not carried out any substantive work on timescales, except to consider what the implications might be of its recommendations to establish partnership arrangements with potential local host communities that might be willing to participate in the process. In the indicative timeline below, therefore, the first ten years represents CoRWM's initial view of the time it might take to get to the start of site investigations for a geological repository, mostly based on its interpretation of overseas experience where partnership arrangements have been attempted[1].

3. Beyond consideration of that first phase, CoRWM carried out no work of its own. However Nirex has provided guidance to Government and the NDA, although without assuming CoRWM's proposed early partnership arrangements. The timeline below combines the work done by CoRWM and Nirex to provide indicative timescales for the period from the time that Government accepts CoRWM's recommendations to the time that the repository would be closed.[2]



14. CoRWM's main assumptions in this timeline are as follows:

- Government accepts CoRWM's recommendations and begins the implementation process in late 2006
- No major new legislation is required
- Any changes in planning regimes do not necessarily shorten the process, because partnerships need time to reach decisions
- The electoral cycle will not result in withdrawal of support for the partnership approach
- There is no significantly accelerated decommissioning
- No new build waste is consigned to the repository

15. The timeline shows what might happen if the implementation process worked reasonably well. It is possible, for example if partnership negotiations were rapid

and site investigations were straightforward, that the time-scale might be shorter. It is also possible that delays at any stage of the process could cause the timescale to become longer.

16. The main stages before site investigations would start are as follows:

Stage 1 - Length: 2 years; Completion: 2008
Government accepts CoRWM's recommendations and establishes the Overseeing and Implementing Bodies.

Individual steps would include:

- Government accepts CoRWM's recommendations;
- determine the structure, nature and accountability of the overseeing and implementation bodies and establish them;
- draft and enact any necessary legislation, if required.

Stage 2 – Length: 2 years; Completion: 2010
Develop and apply scientific screening criteria. Develop framework for partnerships and Involvement Packages.

Individual steps would include:

- develop scientific screening criteria by engaging with interested parties;
- apply screening criteria and reject scientifically unsuitable areas of the UK;
- obtain best practical environmental design options for the disposal concept;
- develop broad framework of partnership arrangements and Involvement & Community Packages by national engagement process;
- issue invitations to local communities to participate in the implementation process.

Stage 3 – Length: 2 years; Completion: 2012
Local communities decide willingness to participate. Develop partnership and Involvement Packages.

Individual steps would include:

- local communities decide their willingness to participate;
- establish provisional partnerships and ensure they are sufficiently representative and workable;
- within the national framework, agree the Involvement Package for each partnership;
- the appropriate elected body for the local community decides whether or not to proceed.

Stage 4 – Length: 4 years; Completion: 2016
Develop Community Packages.

Individual steps would include:

- each partnership develops a Community Package that is acceptable to the local community, which could include the extent and period of flexibility to be incorporated into the design;
- the appropriate elected body decides whether or not to proceed;
- if no partnership decides to proceed, develop a different partnership/package arrangement.

Summary Table 1

Stage	Time	Period (years)	Main Activities
1 – 4	2006-2016	10	Establish organisations and screening criteria, partnerships and packages.
5	2016-2035	19	Site investigation and selection
6	2035-2045	10	Planning permission for repository and construction
7	2045-2110	65	Emplacement (assumes co-disposal)
8	2110-2120	10	Closure

References

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Annex 6 Acronyms and glossary of technical terms

Acronyms

AGR	Advanced Gas-cooled Reactor
AWE	Atomic Weapons Establishment
BE	British Energy
BNFL	British Nuclear Fuels plc
BNG	British Nuclear Group
CORE	Cumbrians Against a Radioactive Environment
CoWRM	Committee on Radioactive Waste Management
Defra	Department for the Environment, Food and Rural Affairs
DTI	Department of Trade and Industry
HAL	High active liquor
HEU	Highly enriched uranium
HLW	High level waste
IAEA	International Atomic Energy Agency
ILW	Intermediate Level Waste
LLW	Low level waste
LLWR	Low Level Waste Repository
LMU	Liabilities Management Unit
LWR	Light water reactor
MOX	Mixed oxide fuel
NDA	Nuclear Decommissioning Authority
NEA/OECD	The Nuclear Energy Agency of the Organisation of Economic Cooperation and Development
NGO	Non-Governmental Organisation
NII	Nuclear Installations Inspectorate
NORM	Naturally occurring radioactive materials
OCNS	Office for Civil Nuclear Security
OSPAR	OSPAR Convention: The Convention for the Protection of Marine Environment of the North-east Atlantic.
PSE	Public and stakeholder engagement
PWR	Pressurised water reactor
QA	Quality assurance
R&D	Research and Development
RCF	Rock characterisation facility
RDW	Reactor decommissioning waste
RSA93	Radioactive Substances Act 1993
RWI	Radioactive waste inventory
RWMAC	Radioactive Waste Management Advisory Committee
THORP	Thermal oxide reprocessing plant
UKAEA	United Kingdom Atomic Energy Authority
VLLW	Very low level waste
WIPP	Waste Isolation Pilot Plant

Glossary of technical terms

Activity - The number of disintegrations per second which occur in a radioactive source. The unit of activity is the Becquerel.

Advanced Gas-cooled Reactor - The reactor type used in the UK's second generation nuclear power plants.

Alpha decay - Spontaneous emission of an alpha particle from a nucleus.

Alpha particle - Nucleus of a helium atom comprising two protons and two neutrons.

Backfill - The material used to fill in and close off the void areas of an underground repository, such as vaults, silos, and drift tunnels, which usually occurs after the radioactive waste has been emplaced; thus "backfilling the waste".

Becquerel (Bq) - S. I. unit of measurement of radioactivity, equivalent to one disintegration per second. A Gigabecquerel is a thousand million Bq; a Terabecquerel is a million million Bq.

Beta decay - Spontaneous emission of a beta particle from a nucleus.

Beta particle - An electron or a positron emitted from the nucleus of an atom during radioactive decay.

Borehole - A cylindrical excavation, made by a drilling device. Boreholes are drilled during site investigation and testing and can also be used for waste emplacement in repositories and monitoring.

CARL - A self-supporting social sciences research project into the effect of stakeholder involvement in decision-making on radioactive waste management. The term comes from the four types of partners in the project: Citizens, Agencies responsible for radioactive waste management, Research social scientists, and Licensing and regulatory authorities.

Ceramic matrix - In this context, use of high performance ceramics, heat and corrosion resistant materials, which are mixed with, and thus immobilise, radioactive waste.

CLAB - The Swedish near surface interim store for spent nuclear fuel.

Cm 2919 - The Command White Paper "Review of Radioactive Waste Policy - Final Conclusions" (1995); although to an extent overtaken by events, this remains an important statement of the UK Government's position on radioactive waste.

Compas - "Comparison of alternative waste management strategies for long-lived radioactive wastes", a project undertaken within the 5th Framework Programme of the European Commission by individuals representing waste management organisations in 15 countries.

Conditioned waste - Radioactive waste that has been treated or processed in preparation for packaging.

COWAM2 - A project involving 12 European countries plus Japan and South Africa aimed at developing decision making processes to be used in radioactive waste management implementation programmes that are thought of as fair and equitable by the stakeholders involved.

Criticality - The point at which a nuclear chain reaction occurs as a result of the concentration of certain types of radioactive materials.

Decommissioning - Generic term to cover all the procedures undertaken once a nuclear installation has ceased operating. Decommissioning covers processes such as defuelling reactors, cleaning out and making safe an installation, dismantling and removal of structures, and waste conditioning prior to storage or disposal.

Decontamination - The complete or partial removal of contamination by a deliberate physical, chemical or biological process.

Defra - One of CoRWM's sponsor departments, along with the Scottish Executive, the Welsh Assembly Government, and the Department of the Environment of Northern Ireland.

Depleted uranium - Uranium containing a lesser mass percentage of Uranium-235 than in natural uranium.

Dilute and disperse - A term normally describing a form of management for radioactive waste where radioactivity is released from a facility as a gas or liquid and is diluted in the air or marine environment.

Encapsulation - Immobilisation of solid waste by mixing it with a matrix material within a container in order to produce a more stable waste form.

EURATOM - The legislative basis for the activities of European Union countries in the nuclear energy field.

Fissile materials - Materials which are capable of undergoing nuclear fission i.e., the spontaneous or impact-induced splitting of a heavy atomic nucleus accompanied by a release of energy. Fissile materials include Uranium-233, Uranium-235, Plutonium-239, Plutonium-241 or any combination of these radionuclides.

Fission products - Radioactive elements produced by nuclear fission through the spontaneous or impact-induced splitting of a heavy atomic nucleus accompanied by a release of energy.

Gamma emission - Emission of high energy, very short wavelength, photons from a nucleus.

Geological disposal - Disposal refers to long-term management options where future access or future changes in management are not intended. Geological disposal usually refers to a long-term management option involving the emplacement of radioactive waste in an engineered repository at between 200 metres and one kilometre underground where the geology (rock structure) provides a barrier against the escape of radioactivity.

Groundwater pathway - When water flows underground, it finds a route through the rock via cracks and fissures to flow to its destination. This is termed the groundwater pathway; drinking water is frequently obtained by drilling into underground reservoirs on the groundwater pathway. This is one route through which radioactivity from a geological repository could be brought back to the surface.

Grouting - A means of encapsulating radioactive waste by mixing it with, for example, cementatious material.

Half-life - The time required for half the number of nuclei of a specific radionuclide to undergo radioactive decay.

Heat-generating waste - Waste that generates heat as it decays, a specific attribute of HLW. The heat generated decreases with time.

High active waste - A term applying to the highly radioactive waste product of the reprocessing of some spent nuclear fuels; sometimes also called "high active liquor" (HAL).

Highly enriched uranium - Uranium in which the proportion of the isotope Uranium 235 has been increased above that at which it occurs naturally.

Hi-View - a computer programme often used in MCDA processes.

Immobilisation - Conversion of waste into a less mobile or non-mobile form by, for example, grouting or encapsulation.

HLW - High level waste; classified in Cm 2919 as wastes in which the temperature may rise significantly as a result of their radioactivity, so that this factor has to be taken account in the design of storage or disposal facilities.

ILW - Intermediate level waste; classified in Cm 2919 as wastes with radioactivity levels exceeding the upper boundaries for LLW but which do not require heating to be taken into account in the design of storage or disposal facilities.

Incineration - A waste treatment process of burning combustible waste which reduces its volume although also produces radioactive residues.

Ionising radiation - Radiation that produces ionisation in matter, for example, alpha particles, gamma rays, x-rays and neutrons. When radiations such as these pass through the tissues of the body, they have sufficient energy to damage DNA.

LLW - Low level waste; classified in Cm 2919 as wastes containing radioactive materials other than those acceptable for disposal with ordinary refuse, but not exceeding 4 GBq per tonne of alpha or 12 GBq per tonne of beta/gamma activity.

LLWR - Low level waste repository: a term sometimes used for the facility sited near the village of Drigg in west Cumbria at which some forms of LLW are accepted for burial. Not all the UK's LLW can be disposed of at the LLWR because of its unsuitability in terms of radioactivity, or its physical or chemical properties, such as liquid content or flammability.

London Dumping Convention - The London Convention of 1972 is an international treaty that limits the wastes that can be disposed of at sea.

Long-lived waste - Radioactive waste that contains radionuclides that have a half-life of more than 30 years.

M-MACBETH - a tool to convert a verbal descriptive scale into a numerical one for the MCDA process.

Magnox - Gas cooled fission reactor using un-enriched uranium as fuel, with magnesium alloy as cladding, the reactor type used in the UK's first generation nuclear power plants.

Mixed oxide fuel - Nuclear fuel composed of a blend of uranium and plutonium.

Multi-barrier concept - Two or more natural or engineered barriers used to isolate radioactive waste in, and prevent radionuclide migration from, a repository.

Nirex - UK Nirex Ltd; a company jointly owned by Defra and the DTI that advises nuclear site operators on the preparation of safety case submissions to the regulators for the conditioning and packaging of radioactive waste.

Nirex Phased Geological Concept - A form of phased geological disposal developed by UK Nirex Ltd.

Neutrons - Electrically neutral sub-atomic particles.

Nuclear fuel cycle - All nuclear fuel related operations associated with the production of nuclear energy, including: the mining and milling of ores, enrichment, manufacture of fuel, operation of nuclear reactors, spent fuel reprocessing, and all related radioactive waste management activities.

Nuclide - An atom specified by its atomic number, atomic mass and energy state.

Overpacking - A secondary (or additional) outer container for one or more waste packages, used for handling, transport, storage and/or disposal.

Packaged radioactive waste - The product of conditioning that includes the waste form and any container(s) and internal barriers, prepared in accordance with the requirements for handling, transport, storage and/or disposal.

Partitioning - The separating out, by physical and chemical methods, of radioactive elements contained in a waste stream to permit their further treatment.

Passive safety - Passive safety describes a situation where no intervention is required to keep the waste in a condition where it poses no threat to health or safety. The waste does not require additional work or processes to be carried out to keep it in a safe condition.

Phased approach - In its report of 1999, the Science and Technology Select Committee of the House of Lords suggested that a 'phased approach' is one in which wastes are stored on the surface while a site is found and a repository is constructed; and the wastes are 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 additional research carried out. 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 recover the wastes.

Phased geological disposal - Generic term covering the phased approach to disposal. One concept has been developed by UK Nirex Ltd - the Nirex "Phased Geological Repository Concept".

Plutonium - A radioactive element, occurring in small quantities in uranium ores but mainly produced artificially by neutron bombardment of uranium for use in nuclear fuel and in nuclear weapons.

Radioactivity - The phenomenon whereby atoms undergo spontaneous random disintegration, usually accompanied by the emission of radiation. Radioactive decay describes the way in which a radioactive material loses activity naturally as a result of this process. The rate at which atoms disintegrate is measured in becquerels.

Pressurised Water Reactor - reactor type used in the UK's third generation nuclear power plants, the only example being Sizewell B.

Radioactive materials - Material designated in national law or by a regulatory body as being subject to regulatory control because of its radioactivity.

Radioactive waste - For legal and regulatory purposes, waste that contains or is contaminated with radionuclides at concentrations or activities greater than clearance levels as established by the regulatory body.

Radionuclide - A nucleus (of an atom) that possesses properties of spontaneous disintegration. Nuclei are distinguished by their mass and atomic number.

RCF - Rock Characterisation Facility; term for an in-situ underground laboratory used for experiments to acquire knowledge about the geological and hydrogeological conditions of the surrounding rock.

Reprocessing - In this context, a physical and chemical operation, the purpose of which is to extract Uranium or Plutonium for reuse from spent nuclear fuel.

Retrievability - Used by CoRWM in a generic sense to mean the ability to withdraw waste from a management facility. Since withdrawal could be effected by a number of different methods, the withdrawal mechanisms can be described in the following ways:

- reversibility: designed into the option to facilitate the recovery of material by reversing the original emplacement process;

- retrievability: designed into the option to facilitate the physical retrieval of waste through means other than reversing the process, such as ensuring access to the waste and having (or being able to have) the retrieval mechanism in place;

- recoverability: addressing the retrievability issue by demonstrating that the waste is technically recoverable through mining or other means.

Separated plutonium - Plutonium that has been separated from spent nuclear fuel by reprocessing.

Short-lived fission product - A short-lived radionuclide, with a half-life of less than 30 years that is produced by nuclear fission.

Short-lived nuclides - Radioactive nuclides with a half-life less than 30 years. Thus, radioactive waste described as short-lived would reduce in activity by a factor of 1000 within 300 years.

Sievert - The S. I. unit of radiation dose; one millisievert (mSv) is a thousandth of a sievert and one microsievert (uSv) is one millionth of a sievert.

Sizewell B - A nuclear power plant in Suffolk operated by British Energy.

Specific activity - Of a radionuclide, the activity per unit mass of that nuclide; of a material, the activity per unit mass or volume of the material in which the radionuclides are essentially uniformly distributed.

Spent nuclear fuel - Irradiated (used) nuclear fuel that cannot any longer be used in a nuclear power reactor.

Stakeholder - Any individual or group which has an interest in the mechanism for, or the outcome of, a process.

Streams - As "material/waste stream", a term used to make a broad distinction between one type of radioactive material or waste and another. The decommissioning of a large nuclear facility could be said, for example, to result in the creation of "a large number of waste streams".

Subduction - In this context, radioactive waste is placed in a subduction zone - an area where one denser section of the earth's crust is moving towards and underneath another lighter section, the result being that the waste will eventually subduct beneath the continental plate and gradually be drawn down into the earth's mantle.

Substitution - The contractual arrangement by which wastes resulting from reprocessing carried out in the UK for overseas customers can be retained and other wastes - equivalent in radiological terms - can be returned. If implemented, substitution would mean that the UK would retain some overseas-owned ILW and LLW and return an additional amount of HLW together with the overseas-owned HLW due, in any case, to be returned.

Surface investigations - Work carried out from the land surface to test the suitability of geology for the possible disposal of radioactive waste. For example, Nirex drilled 28 boreholes around the Longlands Farm site near Sellafield to test its suitability for the proposed RCF.

Tonnes (Te) - Unit of mass (10^6 or 1,000,000 grammes).

Transmutation - The conversion of one element into another. Transmutation is under study as a means of converting longer-lived radionuclides into shorter lived or more manageable radionuclides.

Transuranic waste - Radioactive waste containing elements that have a higher number than Uranium in the periodic table, such as Plutonium, Neptunium, Americium, Curium, etc.

Uranium - A heavy metallic element, radioactive and toxic, easily oxidized, and having 14 known isotopes of which Uranium-238 is the most abundant in nature.

Vitrification - Process of incorporating materials into molten glass. Vitrification is commonly applied to the solidification of liquid high level waste from the reprocessing of spent fuel.

VLLW - Very low level waste; classified in Cm 2919 as wastes which can safely be disposed of with ordinary refuse.

Committee on Radioactive Waste Management
3/H26 Ashdown House, 123 Victoria Street, London, SW1E 6DE
Telephone: 020 7082 8496
E-mail: contact@corwm.org.uk
Website: http://www.corwm.org.uk