CORWM'S ADVICE TO GOVERNMENT ON OPTIONS FOR THE ACCELERATION OF THE IMPLEMENTATION OF GEOLOGICAL DISPOSAL

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EXECUTIVE SUMMARY

1. This paper is a response to a request from the Department of Energy and Climate Change (DECC) for CoRWM's advice on the 2011 review of options for accelerating the geological disposal programme carried out by the Radioactive Waste Management Directorate (RWMD) of the Nuclear Decommissioning Authority (NDA). The paper gives CoRWM's views on:
    - the key issues involved in deciding whether and how to accelerate the geological disposal programme
    - the methodology used by RWMD in its assessment of acceleration options
    - the disposal concepts considered by RWMD
    - RWMD's future work on acceleration
    - future Government decision making on acceleration.

CoRWM's Views on the Key Issues

2. CoRWM takes the view that it is not practicable to bring forward the 2040 date for first emplacement of any wastes in a geological disposal facility (GDF). Consideration of the activities to be carried out before first waste emplacement, and of international experience, suggests that it will be challenging to meet the 2040 date and might well not be possible to meet an earlier date.

3. CoRWM also takes the view that it is not desirable to bring forward the 2040 first emplacement date. The Committee considers that the disadvantages in adopting any specific option for bringing forward the 2040 date would considerably outweigh the advantages. As far as CoRWM can ascertain, there are no strong health and environmental risk drivers for moving this date forward and there may be no cost savings for NDA or the UK in doing so.

4. Rather than adopting a specific option to bring forward the 2040 date, it would be better to continue efforts to make the implementation of geological disposal as efficient as possible, consistent with technical, stakeholder and public needs. This would ensure that the momentum in the geological disposal programme is maintained, without the disruption that would be caused by adopting a new and overly challenging target date for first emplacement.

5. However, CoRWM concludes that there would be considerable advantages in bringing forward the 2075 date for first emplacement of high level waste (HLW) and legacy spent fuels and the 2130 date for first emplacement of new build spent fuel. Further work is required to identify the best means to do this and to determine the optimum dates for first emplacements of HLW and various types of spent fuel. It would also be worthwhile to shorten the emplacement programmes for HLW and spent fuels.

CoRWM's Advice on the Way Forward

6. CoRWM considers that RWMD's future work on acceleration should focus on bringing forward the dates for first emplacement of HLW, legacy spent fuels and new build spent fuels and on shortening the emplacement programmes for intermediate level waste (ILW), HLW and all spent fuels. It would be better to devote most effort to examining acceleration options for each group of wastes and types of spent fuel separately, rather than to further study of combinations of options for all wastes and spent fuels. RWMD

should keep an open mind on disposal concepts other than those for which it expresses a preference in its 2011 report; it may also need to identify different concepts for rocks other than higher strength ones.

7. CoRWM encourages Government to follow a structured approach, with stakeholder consultation, for the decision on whether and how to accelerate the geological disposal programme. If this were to be modelled on the current NDA approach to major strategic decisions, the next step would be identification of credible options for acceleration and publication of a report for comment. This would be followed by identification of and consultation on the preferred option. Consultees' views would be considered when Ministers take the decision on acceleration.

INTRODUCTION

8. The baseline programme of the Nuclear Decommissioning Authority's (NDA's) Radioactive Waste Management Directorate (RWMD) for the implementation of geological disposal has the following dates for first emplacement of the various types of higher activity wastes (HAW):
    - legacy intermediate level wastes (ILW): about 2040
    - legacy high level waste (HLW) and spent fuels: about 2075
    - new build spent fuel: about 2130.

9. These dates have been the planning assumptions for several years and it is timely to review them. CoRWM therefore welcomed the Minister of State for Energy's request to RWMD to consider means by which the programme for implementation of geological disposal could be accelerated.

10. CoRWM scrutinised RWMD's assessment of options for acceleration by attending workshops, holding informal discussions with RWMD and commenting to RWMD on drafts of the summary paper on the results of the assessment. The Committee also provided informal comments to the Department of Energy and Climate Change (DECC) on the version of the RWMD summary paper that preceded the one discussed at the meeting of the Geological Disposal Implementation Board (GDIB) on 6 December 2011 (DECC, 2011).

11. In January 2012 CoRWM received a request from DECC for advice on RWMD's review of options for acceleration of the geological disposal programme (NDA, 2011a). The request asked for an assessment of RWMD's work on acceleration. It stated that it would be helpful if this included CoRWM's views on the robustness of the process that RWMD used in developing and assessing a long list of options, as well as views on the analysis and conclusions presented in the RWMD report (NDA, 2011a).

12. This paper is the response to DECC's request. The main text gives CoRWM's views on:
    - the key issues involved in deciding whether and how to accelerate the geological disposal programme
    - the methodology used by RWMD in its assessment of acceleration options
    - the disposal concepts considered by RWMD
    - RWMD's future work on acceleration.

13. Details of the reasoning behind the views are in Annex A. The paper also contains advice to DECC on making decisions on acceleration.

14. In its report on its work (NDA, 2011a), RWMD considers three scenarios, that is combinations of acceleration options. For the convenience of readers, the main features of these scenarios are summarised in Annex B.

CORWM'S VIEWS ON THE KEY ISSUES

Shortening MRWS Stages 4-6

15. All options for bringing forward the 2040 date for first emplacement of any waste involve shortening Stages 4-6 of the Managing Radioactive Waste Safely (MRWS) process for siting a geological disposal facility (GDF). It is therefore important to consider whether such shortening is feasible in general, before examining specific options.

Current Durations of Stages 4-6

16. Current RWMD planning (NDA, 2010) has the durations of Stages 4-6 as:
    - Stage 4 (site identification and assessment): about 5 years
    - Stage 5 (surface-based investigations): about 10 years
    - Stage 6 (underground operations from construction of the first access shaft or drift to first waste emplacement, including underground characterisation and R&D): about 15 years.

17. Thus if West Cumbria decided to participate further in the MRWS process, and all went well from then on both technically and in the local communities, the earliest that waste emplacement could begin would be about 2042.

Comparisons with Other Countries

18. RWMD plans have been benchmarked against other countries' experience and plans for geological disposal. However, it is clear that it will be challenging for RWMD to implement them. Unlike other countries, the UK has no experience of underground site characterisation or research and development (R&D) at its own potential GDF site. Further, the schedule does not include any contingency for resolving unforeseen technical problems, for additional stakeholder and public consultation, or for delays in community or Government decision making.

19. Experience in other countries suggests that allowance should be made for all these eventualities. The US Nuclear Technical Review Board studied 13 national programmes for the long-term management of high level waste and spent nuclear fuel (US NWTRB, 2011). It concluded that in each of these programmes the issues proved more complicated and protracted than expected. It stated that: "*what was formerly viewed as a relatively simple technical task is now recognized as a complex socio-technical problem involving political negotiations and institutional design challenges, as well as path-breaking scientific and engineering analyses*".

Shortening Stage 4

20. CoRWM agrees with RWMD's conclusion (NDA, 2011a) that there are no practicable generic options for shortening Stage 4 substantially. It also agrees with RWMD that, at present, attempting to shorten Stage 4 could put the voluntarism and partnership approach to GDF siting at significant risk. While there may be site specific factors that could allow Stage 4 to be shortened in due course, CoRWM considers that it is not appropriate to rely on these in planning the geological disposal programme. Rather the emphasis should be on continuing to proceed as efficiently as possible, taking into account stakeholder and public views.

Shortening Stage 5

21. RWMD's current plan for Stage 5 (NDA, 2010) is to carry out a major phase of geophysical investigations and to follow this by several phases of drilling, and performing tests in, exploratory boreholes. There would also be some geophysical investigations during the borehole phases. One option identified by RWMD for shortening Stage 5 is to bring forward the major phase of geophysical investigations from Stage 5 to Stage 4. Another option is to carry out geophysical investigations in parallel with drilling initial exploratory boreholes.

22. CoRWM considers that carrying out some geophysical investigations in Stage 4 is advisable, whatever is decided about acceleration (CoRWM doc. 2975). However, the Committee believes that bringing forward the major phase of geophysical investigations to Stage 4 would not be sensible because it would probably entail doing investigations at some sites that are not then carried forward to Stage 5. CoRWM also considers that no exploratory boreholes should be drilled until there is sufficient geophysical data to assist choices of locations for them.

23. CoRWM takes the view that the most appropriate procedure for Stage 5 is to carry out several phases of surface-based investigations, with iterations between geophysical investigations and drilling exploratory boreholes in each phase. In this way the siting of all the exploratory boreholes can be informed by geophysical investigations. It is also important to allow sufficient time for analysis of the data gained in each phase before proceeding to the next. CoRWM believes that it is not desirable to adopt either of the options identified by RWMD for shortening Stage 5 and that allowing 10 years for Stage 5, as in current RWMD planning, is not unreasonable.

Shortening Stage 6

24. CoRWM takes the view that it would not be prudent to plan to shorten Stage 6 without having information from Stage 5 about the potential host rock(s) for a GDF. Further, the Committee considers that it will not be possible to estimate the time required for underground characterisation until access has been gained to the potential host rock(s). It is also essential not to underestimate the time required for underground R&D prior to first waste emplacement (CoRWM doc. 2543), especially because the UK has no experience of planning and carrying out a major programme of underground experiments specific to its wastes and geological settings.

25. CoRWM regards 15 years as a reasonable estimate of the duration of Stage 6 for current planning purposes. It would caution against reducing this duration until the MRWS process is further advanced.

Potential Reductions in Hazards, Risks and Costs of Radioactive Waste Management

Reductions in Hazards and Risks

26. Acceleration of the implementation of geological disposal would reduce radioactive waste related hazards and health and environmental risks at nuclear sites earlier than presently envisaged. The issue is whether these reductions would be worthwhile.

27. RWMD's report (NDA, 2011a) presents no analysis of the potential reductions in hazards and risks arising from acceleration. It states that there will be reductions but provides no qualitative or quantitative evidence to support these statements.

28. From CoRWM's own qualitative analysis for all UK nuclear sites (Annex A), the Committee concludes that there are no strong health and environmental risk drivers for moving forward the 2040 date for first emplacement of ILW in a GDF. At Sellafield the

hazard and risk reduction produced by early despatch of ILW to a GDF would be very small compared to that achieved by retrieving wastes from the Legacy Ponds and Silos and decommissioning these facilities. At other nuclear sites operational ILW is safely stored and most decommissioning ILW has yet to arise.

29. Early emplacement of HLW in a GDF would reduce hazards and risks at Sellafield. However, the reductions would be small compared to those achieved by completing vitrification of high activity liquid waste.

30. On grounds of hazard reduction at Sellafield, there is a clear case for beginning emplacement of unreprocessed spent AGR fuel in a GDF before 2075. Earlier emplacement of Sizewell B spent fuel in a GDF would achieve a modest risk reduction at the Sizewell site. Further work is required to determine the optimum times for beginning disposal of AGR and Sizewell B spent fuel.

31. CoRWM understands that the date of 2130 for the start of emplacement of new build spent fuel in a GDF is based simply on the assumption that the disposal of legacy ILW, HLW and spent fuels will be completed before the disposal of new build spent fuel begins. Prospective new build operators are considering their arrangements for interim storage of new build spent fuel, including the type of storage system (wet or dry) and whether storage will be at each station site, in regional stores or in a central store. If a GDF was available to take new build spent fuels well before 2130, it might be possible to transfer fuel directly from stations' ponds to a GDF. This would reduce the risks of storing spent fuels at stations or in regional stores or a central store.

Reductions in Costs

32. The cost estimates given in the RWMD report (NDA, 2011a) are stated to be those for the geological disposal programme but it is unclear how they were derived. In particular, CoRWM notes that the baseline cost in the report (£4.2 billion, discounted (NDA, 2011a)), is not the same as that used by NDA in its provision to meet its liabilities (£3.8 billion, discounted (NDA, 2011b)). The baseline cost must therefore include geological disposal costs that are to be met by organisations other than NDA but the RWMD report does not state what these costs are or which organisations will pay them.

33. The RWMD report gives no estimates of the overall costs of acceleration to the whole NDA estate or to the whole of the UK nuclear industry (civil and defence). (For example, there are no estimates of the potential reductions in the costs of interim storage.) From its own qualitative analysis (Annex A), CoRWM concludes that there would be no major advantages in terms of overall costs to NDA or the UK in bringing forward the 2040 date for first emplacement of ILW. However, there could be considerable cost advantages in bringing forward the 2075 date for first emplacement of HLW and legacy spent fuels, and in bringing forward the 2130 date for first emplacement of new build spent fuel.

Shortening Emplacement Programmes

34. CoRWM notes that there would be advantages in terms of hazard and risk reduction at nuclear sites in shortening the times it will take to emplace legacy and new build wastes and spent fuels in a GDF. In addition, shortening emplacement times would reduce the time for which a GDF needs to be operational, and thus reduce disposal costs. The Committee considers that the issue of shortening emplacement programmes could have been given more emphasis in RWMD's report (NDA, 2011a).

Other Efficiencies in the Implementation of Geological Disposal

35. The RWMD report (NDA, 2011a) describes an examination of specific options for accelerating the geological disposal programme. It should also be possible to accelerate the programme by carrying out its various stages more efficiently. CoRWM is aware that RWMD takes account of the need for efficiency in all its work on the implementation of geological disposal. The Committee notes that there may be information from the examination of specific acceleration options that will be helpful for RWMD in doing this in future.

RWMD METHODLOGY, DISPOSAL CONCEPTS AND FUTURE WORK

RWMD Methodology for Its Options Review

Derivation of Long List of Acceleration Options

36. A CoRWM member attended the two RWMD workshops at which options for accelerating various parts of the geological disposal programme were discussed. CoRWM also had an opportunity to discuss the acceleration work with RWMD at a closed meeting that took place between the two workshops. Most of the workshop attendees were from RWMD but there were also some from other parts of NDA, from DECC and from Welsh Government.

37. The options considered at the workshops ranged from relatively minor changes to the baseline programme to disposal concepts that implied radical changes. CoRWM found the option identification process to be thorough and was satisfied that no major options had been omitted, given that the work was focused largely on higher strength rocks. Had the work not been so focused it would have been advisable to have participants from a wider range of backgrounds, including those with experience of geological disposal programmes for other rock types.

Scenario Approach

38. Combining options into scenarios began at the second workshop. CoRWM considers that the use of scenarios was an appropriate approach for this first RWMD study of acceleration options. It allowed analysis of acceleration of various parts of the geological disposal programme, while always considering the programme as a whole.

Published Documentation

39. RWMD's report on its acceleration work (NDA, 2011a) is relatively short (about 50 pages). It contains only the results of the study and there are no references to any published documents on interim stages, such as reports of the workshops (para 36). Few details are given of some of the underlying assumptions (*e.g.* on costs, para 32), either in the report or by reference to other documents. There are also some unsupported statements in the report (*e.g.* on potential hazard and risk reductions, para 27).

40. Overall, CoRWM would have expected RWMD to publish more detailed documentation of its work. The Committee recognises that this may have been difficult in the short time that RWMD was given to carry out the study. Nevertheless, it considers that, in the interests of transparency, further documentation should now be published.

Disposal Concepts

41. In its report (NDA, 2011a), RWMD considers the following disposal concepts that differ from its reference ones:
    - disposal vaults for some ILW at shallower depth
    - disposal of HLW in vaults, rather than in holes in the floors of tunnels

- underground storage of spent fuels prior to disposal
- use of multi-purpose containers (MPCs) for spent fuels
- disposal of HLW in deep boreholes.

42. Details of CoRWM's views on these concepts are in Annex A. They can be summarised as follows.

43. The Committee considers that there are no technical, financial or programmatic advantages in early construction of vaults at shallower depth to take small quantities of ILW. Disposal of HLW in vaults is worth exploring but the difficulties of making operational and post-closure safety cases should not be underestimated.

44. Underground storage of spent fuels has a number of significant disadvantages, including high programme and financial risks, and difficulties for local communities and for regulators. The use of MPCs for spent fuels merits further study. CoRWM notes that RWMD's analysis of the use deep boreholes raises, but does not answer explicitly, the issue of whether it is enough to keep a watching brief on this option.

45. CoRWM also notes that, in the RWMD acceleration work, several of the disposal concepts and some of the packaging assumptions appear to be largely specific to what RWMD terms "higher strength rock". Until MRWS Stage 4 has been carried out in at least one part of the UK it will not be known whether a GDF is likely to be located in this type of rock.

Future RWMD Work on Acceleration

46. While the scenario approach was appropriate for the initial RWMD assessment of acceleration, CoRWM considers that future work would be best carried out by considering acceleration options for each waste type. As indicated above (paras 15-34), the Committee takes the view that this work should focus on:
    - shortening the ILW emplacement programme, leaving the planned date of first emplacement (2040) unchanged
    - bringing forward the planned dates of first emplacement of HLW, legacy spent fuels and new build spent fuels
    - shortening the emplacement programmes for HLW and spent fuels
    - improving the efficiency of the implementation of geological disposal as much as is practicable, consistent with the voluntarist and partnership approach.

47. CoRWM broadly agrees with RWMD's proposal to concentrate its work over the next 12 months on the options in scenario 1 in its report (NDA, 2011a). However, CoRWM takes the view that, in doing so, RWMD should not assume that it is feasible or necessary to meet a 2036 date for first emplacement of ILW or a 2041 date for first emplacement of HLW.

48. The Committee also considers that RWMD should not focus entirely on the options in scenario 1. Some of the elements of the other scenarios merit further consideration (*e.g.* use of MPCs for spent fuels, deep borehole disposal for HLW and legacy and new build spent fuels). Furthermore, the disposal concepts considered by RWMD in its acceleration work to date are largely specific to higher strength rocks. Other concepts would need to be assessed if the sites identified in MRWS Stage 4 include other types of rock.

49. CoRWM encourages RWMD to publish as much information as is practicable on its work on acceleration. This should include the implications of acceleration options for the whole

NDA estate and for other existing and potential producers of HAW, spent fuels and nuclear materials that are candidates for geological disposal.

GOVERNMENT DECISIONS ON ACCELERATION

50. CoRWM advises Government to give careful consideration to the timing of the decision on adopting an acceleration option or options, and to involving stakeholders in making the decision. In particular, the Committee considers that it would be unwise to change the 2040 date before a decision has been taken in West Cumbria on whether or not to participate further in the MRWS siting process. Postponing any change would allow any communities that have decided to participate to be involved in forward planning, which would be more consistent with the partnership approach set out in the 2008 MRWS White Paper.

51. CoRWM notes that NDA has a well-structured approach to making major strategic decisions about its work programme[1]. This involves identifying "credible options" (what could be done) and a "preferred option" (what should be done), before the final decision (what will be done) is made by the NDA Board. NDA usually publishes information for comment at the credible option stage and carries out stakeholder consultation at the preferred option stage. If an obvious preferred option emerges from the work on credible options the two stages are brought together. Consultees' views form an input to the NDA Board's decision.

52. CoRWM encourages Government to follow a similar structured approach, with stakeholder consultation, for the decision on acceleration of the geological disposal programme, although the decision in this case will be for Ministers. The Committee notes that RWMD considers that its work to date on acceleration has been a precursor to the definition of credible options (NDA, 2011a). It also notes that RWMD plans to consult various stakeholders over the next year, as it carries out work on credible options. However, there appear to be no Government plans for formal consultation, only discussions with the small number of stakeholders who attend GDIB meetings (DECC, 2011).

53. In connection with decision making on the geological disposal programme, CoRWM would draw Government's attention to the report of the Blue Ribbon Commission in the United States (BRC, 2012). The Commission states that: "*transparency, flexibility, patience, responsiveness, and a heavy emphasis on consultation and co-operation*" are necessary in all aspects of the implementation of a geological disposal programme. It reached this conclusion after a wide-ranging review of experience of successful and unsuccessful attempts to implement geological disposal in the United States and other countries.

[1] Details and examples are in the Strategy section of the NDA website, www.nda.gov.uk. CoRWM has discussed the process with NDA (*e.g.* CoRWM doc. 2923).

REFERENCES

CoRWM Documents

CoRWM doc. 2543. *Report on National Research and Development for Interim Storage and Geological Disposal of Higher Activity Radioactive Wastes, and Management of Nuclear Materials.* Report to Government. December 2009.

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CoRWM doc. 2975. *Letter to DECC on the Possible Need for Geophysical Surveys in MRWS Stage 4.* October 2011.

CoRWM doc. 2994. *Assessment of the Generic Disposal System Safety Case.* Position Paper. March 2012.

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BRC, 2012. *Blue Ribbon Commission on America's Nuclear Future. Report to the Secretary of Energy*. January 2012.

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Annex A

Details of CoRWM's Reasoning

Shortening MRWS Stages 4-6

Shortening Stage 4

54. RWMD concludes (NDA, 2011a) that the potential for shortening Stage 4 is not great and that pursuing means of doing so would pose significant risks for the voluntarist and partnership approach. However, RWMD identifies a number of site specific factors that could, in principle, allow Stage 4 to be shortened (*e.g.* use of a site where some characterisation data are already available, or a site where services already exist).

55. CoRWM agrees that there are no practicable options for shortening Stage 4 radically. The emphasis should be on proceeding as efficiently as possible, taking into account stakeholder and public views, especially in local communities. It would not be appropriate for planning purposes to rely on site specific factors to shorten Stage 4.

Shortening Stage 5

56. RWMD identifies two options for shortening Stage 5:
    - bringing forward most of the geophysical investigations from Stage 5 to Stage 4
    - undertaking geophysical investigations in parallel with drilling initial exploratory boreholes, rather than carrying out most of the geophysical investigations first.

57. Carrying out some geophysical investigations in Stage 4 is advisable, whatever is decided about acceleration (CoRWM doc. 2975). Carrying out all geophysical investigations in Stage 4 is unlikely to be practicable. It would almost inevitably involve doing work that later turned out to be nugatory. It would bring costs forward and mean that RWMD would need to employ site characterisation contractors earlier. RWMD would also need to bring forward the development of its site characterisation plans and any R&D needed to support them. Communities would inevitably feel rushed and there might be objections to extensive geophysical investigations.

58. Good site characterisation practice is to use the results of geophysical investigations to assist borehole siting. Failure to build up a good picture of the geology first would make it likely that one or more boreholes would not be sited where they could be used to gain the most information. It could also result in more boreholes needing to be drilled than would otherwise be the case. In addition, if applications for planning permission for boreholes were not based on adequate supporting evidence, permission could be refused.

59. In current RWMD plans for Stage 5 (NDA, 2010) there is a phase of geophysical investigations, followed by several phases of exploratory boreholes. It is stated that geophysical investigations will continue into the borehole phases.

60. The Committee considers that the most appropriate procedure is to have several phases of surface-based investigations, with iterations between geophysical investigations and drilling exploratory boreholes in each phase (CoRWM doc. 2994). In this way all the exploratory boreholes can be sited on the basis of geophysical data. The time to carry out such a phased, iterative procedure will depend on site specific factors. For planning purposes, the 10 years in RWMD's current programme does not seem unreasonable.

Shortening Stage 6

61. The underground operations to be carried out in Stage 6 are:

- construction of the access shafts or drift
- underground characterisation of the volume of rock where the first vault(s) or tunnel(s) for disposal of wastes will be constructed
- underground R&D
- construction of the first disposal vault(s) or tunnel(s).

62. There will also need to be detailed GDF design work in Stage 6, taking account of underground site characterisation data as they become available.[2]

63. It would not be sensible to plan to shorten Stage 6 without having information from Stage 5 about the potential host rock(s) for a GDF. Further, until the first access shaft or drift is sunk and underground site characterisation is underway, it will not be possible to estimate how much further characterisation work will be needed before the construction of the first disposal vault(s) or tunnel(s) begins. Experience of underground construction is that conditions can differ, sometimes greatly, from those expected from surface-based investigations.

64. It is also essential not to underestimate the time required for underground R&D prior to first waste emplacement (CoRWM doc. 2543). There have been no underground experiments specific to UK wastes and UK geological settings, so more underground R&D will be needed than in some other countries that are implementing, or plan to implement, geological disposal.

Potential Reductions in the Hazards, Risks and Costs of Waste Management

Legacy ILW at Sellafield

65. If a GDF was available before 2040 it might be possible to begin emptying existing ILW stores at Sellafield at earlier dates. Another possibility would be to route some types of ILW directly from packaging plants to a GDF, thus avoiding the need to construct some new stores. Both courses of action would reduce risks at the Sellafield site. However, the reduction would be insignificant compared to that produced by retrieving ILW from the Legacy Ponds and Silos and conditioning and packaging it, and decommissioning the ponds and silos and conditioning and packaging the decommissioning wastes. It is unclear whether, in discounted terms, savings in storage costs would outweigh increases in disposal costs.

Other Legacy ILW

66. Early removal of existing ILW from Magnox sites while the reactors are still in care and maintenance ("safestore") would lead to small risk reductions and increases in discounted costs. Current plans are to dismantle Magnox reactors and clear their sites in the period 2070 to 2100. The ILW generated by dismantling will be packaged and sent to a GDF, without any interim storage. Only if Magnox site clearance was brought forward by several decades would there be any advantages in having a GDF available before 2040. The cost implications of earlier site clearance would be considerable and in the past NDA has not been able to make a business case for this course of action.

67. Acceleration of geological disposal would be unlikely to affect the plans to move ILW from Harwell to Sellafield or from Winfrith to another site. The situation for AGR sites is probably similar to Magnox. For the Ministry of Defence (MoD), there might be cost

[2] It should also be noted that this cycle of underground characterisation, detailed design and construction will need to be repeated for each phase of a GDF, once waste emplacement in the first phase has begun. It is not simply a matter of "construct and commission", as shown in the RWMD report (NDA, 2011a).

savings in storage of ILW at Aldermaston and in storage of ILW from submarine dismantling.

HLW

68. Early emplacement of HLW in a GDF would reduce hazards and risks at Sellafield but not to the same extent as vitrifying high activity liquid waste. As with ILW (para 65), the reduction achieved by early emplacement in a GDF would be small compared to that achieved by dealing with the Legacy Ponds and Silos.

69. A key cost issue for HLW is whether it is possible to avoid building a replacement for the Vitrified Product Store (VPS) at Sellafield. The design life of the VPS is due to end in 2040 (NDA, 2009) and current plans are that it will be emptied by that date. Removal of HLW from store, packaging it in disposal containers and transporting it to and emplacing it in a GDF is estimated to take 20 years (NDA, Sellafield Ltd, NMP, 2011). RWMD has indicated that this time might be shortened.

70. If the time to empty the present VPS was halved and a GDF was available by 2030, then it would be possible to avoid building a replacement VPS. If the lifetime of the present VPS could be extended by 10 years, then having a GDF available in 2040 could still avoid building a replacement VPS.

71. A further possibility would be to package HLW in disposal containers on removal from the present VPS. This would enable the HLW to be stored in a less massive and cheaper building, saving part of the costs of replacing VPS. Such an option would provide the means to bring forward the start of emplacement of HLW in a GDF to well before the current date of 2075, without tying the programme to a tight timescale for decommissioning the present VPS or constructing the part of a GDF that will hold HLW.

Legacy Spent Fuels

72. It is planned that Magnox fuel will all be reprocessed and that this will also be the management route for some exotic fuels (*e.g.* Dounreay Fast Reactor breeder fuel). Other exotic fuels are likely to be treated as waste and the discussion above for ILW largely applies to these.

73. The present plan is to store unreprocessed AGR fuel in the THORP Receipt and Storage Pond, then package it and dispose of it in a GDF. Packaging of AGR fuel and export to a GDF is currently scheduled for 2075-87 (NDA, Sellafield Ltd, NMP, 2011). If the safety case cannot be made for wet storage of AGR fuel for periods of the order of 50-60 years, then dry storage will be needed.

74. Early availability of a GDF for unreprocessed AGR fuel would shorten the storage period and make it less likely that dry storage was required. It could thus lead to cost savings, although these would be offset by earlier disposal costs and perhaps earlier costs of decommissioning the THORP Receipt and Storage Pond. Removal of AGR fuel from the Pond to a GDF would reduce risks at Sellafield, but by a small amount compared to dealing with the Legacy Ponds and Silos.

75. On hazard reduction grounds there is a clear case for beginning emplacement of AGR fuel in a GDF well before 2075. However, it is not clear when the optimum time would be or whether beginning emplacement in 2040 or earlier, as in some RWMD scenarios, is either feasible or desirable.

76. Spent fuel from Sizewell B is to be stored dry at the station in casks that may also be used for disposal. Early emplacement in a GDF would lead to a modest risk reduction. It

would increase disposal costs but could enable earlier decommissioning of Sizewell B and clearance of the site, which might have advantages to EDF. As with AGR fuel, there would be advantages in beginning emplacement of Sizewell B fuel in a GDF before 2075 but it is unclear whether starting emplacement in or before 2040 would be practicable or worthwhile.

New Build Spent Fuel

77. The current date of 2130 for the first emplacement of new build spent fuel is based simply on the assumption that all legacy ILW, HLW and spent fuels will be emplaced first. It has always been clear that this assumption would need to be re-examined.

78. New build spent fuel will initially be stored in the power station ponds. Prospective new build operators are considering whether it should be moved to other wet or dry storage facilities on station sites, or be moved to a regional or central store. Having a GDF available well before 2130 could enable new build spent fuel to be transferred from station ponds to the GDF, thus avoiding the need to construct additional wet or dry stores on station sites, or regional stores or a central store. This would lead to considerable cost reductions, as well as to reductions in hazards and risks at storage sites.

79. Further work is required to determine the optimum time for a GDF to be available to take new build spent fuel (CoRWM doc. 2878). However, there would seem to be no great advantages in having such a GDF before 2040. Not a great deal of spent fuel will have been generated by this time and experience in other countries, and at Sizewell B, shows that it is possible to store PWR fuel in ponds for several decades without its condition deteriorating significantly.

Disposal Concepts

ILW Vaults at Shallower Depth

80. RWMD has considered the possibility of having disposal vaults for some ILW at shallower depth. Such vaults would be available earlier, thus enabling ILW emplacement to begin before 2040.

81. A disadvantage of concepts with shallower ILW vaults is that they complicate GDF operations, making it more difficult to make the operational safety case. They might also be more expensive. (Deeper ILW vaults would still be required and the marginal costs of emplacing short-lived/low toxicity ILW in these might be lower than placing them in separate shallower vaults.) There is also the issue of the quantities of short-lived and low toxicity ILW suitable for disposal in shallower vaults. The RWMD report indicates that emplacement of ILW in shallower vaults would only take about 2 years and there would then be a gap in GDF operations. It appears to CoRWM that early emplacement of such small quantities of wastes would not be worthwhile.

Disposal of HLW in Vaults

82. In this concept canisters of HLW are assumed not to be placed in thick-walled disposal containers and emplacement is assumed to be by stacking stillages of HLW canisters in vaults, rather than by placing disposal containers in holes in the floors of tunnels. This saves space and, because the HLW canisters are handled in stillages, there are fewer transport and emplacement movements. While initial work suggests this is feasible, further analysis would be required to determine whether the operational and post-closure safety cases could be made.

Underground Storage of Spent Fuels Prior to Disposal

83. One option considered by RWMD has storage of spent fuels underground before a safety case has been made for their disposal. CoRWM believes that this option would create considerable difficulties for regulators because their requirements for storage are very different to those for disposal. Stores are regulated on the basis that wastes will be retrieved and regulatory requirements relate to maintaining the store in a safe condition until retrieval occurs. In contrast, a disposal facility is regulated on the basis that there will be no waste retrieval, although retrieval is possible.

84. The option would also be problematic for communities local to a GDF, who would not know whether they were being asked to accept spent fuel storage or spent fuel disposal. In addition there is the programme and financial risk that the safety case for disposal could not be made and the spent fuel would have to be removed.

Use of Multi-Purpose Containers for Spent Fuels

85. In two of the scenarios studied by RWMD AGR, Sizewell B and new build spent fuels are packaged in Multi-Purpose Containers (MPCs), that is containers that are designed to be suitable for storage, transport and disposal. Studies of the use of such containers for UK spent fuels are at an early stage and no safety cases have yet been made for transport or for disposal.

Deep Boreholes

86. Deep borehole disposal is not at such an advanced stage of development as the various “mined repository” concepts. In its acceleration work, RWMD has included it in one scenario, but only for HLW. In other work RWMD is keeping a watching brief on deep borehole disposal for HLW and spent fuels.

87. The issue for decision in the light of the acceleration work is whether a watching brief is enough or whether deep borehole disposal should be studied by the UK to a greater extent than at present. This could be done by greater participation in R&D in other countries (particularly the US) and/or by setting up a UK R&D programme.

Annex B

Main Features of the Scenarios Analysed by RWMD

88. For the convenience of readers, this annex summarises the main features of the three scenarios analysed by RWMD (NDA, 2011a).

Scenario 1

89. RWMD states that this scenario is the existing programme with logic links, timings and sequences reduced and packaging assumptions challenged.

90. Disposal concepts would be as in the baseline programme, assuming higher strength rocks. Construction of a GDF would begin in 2028, with vaults for shielded ILW being constructed first. Emplacement of shielded ILW would begin in 2036. Construction of vaults for unshielded ILW would proceed in parallel with construction of tunnels for HLW and legacy spent fuels. Emplacement of unshielded ILW would begin in 2040 and emplacement of HLW and legacy spent fuels in 2041.

91. Completion dates for emplacement would be:
    - shielded ILW: 2038
    - unshielded ILW: 2120 (but about half by 2060, then emplacement at a slower rate as waste arises)
    - HLW and AGR spent fuel: 2060
    - Sizewell B spent fuel: 2080.

92. Capacity to take new build spent fuels would be available from about 2080. However, the date for starting emplacement of these fuels would depend on the length of time for which they need to be stored to allow their thermal output to reduce.

93. The cost of scenario 1 would be £4.3 billion (discounted), which is slightly higher than the cost of the baseline programme of £4.2 billion (discounted).

Scenario 2

94. RWMD describes this scenario as staged site characterisation, safety cases, permissioning and disposal for various groups of wastes, with some modifications made to disposal concepts.

95. Shielded ILW would be disposed of in vaults at a depth of about 300m, while other wastes and spent fuels would be disposed of at a depth of about 650m. HLW would be placed in vaults, rather than in holes in the floors of tunnels, without a disposal overpack. Construction of the vaults for shielded ILW and HLW would proceed in parallel, after a phase of site investigations and permissioning that covered only these vaults.

96. Site investigations for unshielded ILW and spent fuels would begin while the shielded ILW and HLW vaults were being constructed. The unshielded ILW vaults would be as in the baseline programme. Spent fuels would be disposed of in MPCs in vaults, with backfilling delayed until after a period of cooling. There might also be a vault at 650m for shielded ILW that arises late or is too long-lived for disposal at 300m.

97. Dates for emplacement in scenario 2 would be:
    - shielded ILW at 300m: 2029-2031
    - HLW: 2033-2035
    - unshielded ILW: 2040-2120 (as in scenario 1)

- AGR spent fuel: 2040-2042
- Sizewell B spent fuel: 2042-2043
- new build spent fuels: 2045 onwards.

98. The cost of the scenario would be £4.2 billion (discounted), which is the same as the cost of the baseline programme.

Scenario 3

99. RWMD describes this scenario as staged site characterisation, safety cases, permissioning and disposal for various groups of wastes, with significantly different disposal concepts.

100. Short-lived shielded ILW would be disposed of in vaults at a depth of less than 200m. HLW would be disposed of in deep boreholes (3-4km). Spent fuels would be packaged in MPCs and emplaced in vaults that operated as stores in the first instance, with a safety case for use as disposal vaults being made later. Unshielded ILW and longer lived shielded ILW would be placed in vaults at a depth of about 650m, as in the baseline programme. Construction of the shallow vaults would begin first, followed by construction of the vaults for spent fuels, then the vaults for unshielded ILW and the boreholes for HLW.

101. Dates for first emplacement of wastes and spent fuels would be:
- short-lived, shielded ILW: 2029 (with completion of emplacement in about 2 years)
- unshielded ILW: 2040 (with completion by 2120, as in scenario 1)
- HLW: 2041 (with completion in about 24 years if boreholes were drilled and filled sequentially)
- legacy spent fuels: 2033 (for storage)
- new build spent fuel: about 2040 (for storage).

102. The vaults for spent fuels might need to be kept open for as long as 300 years to allow the fuels to cool, before being backfilled and sealed as a disposal facility (provided the safety case for disposal could be made). The rest of the GDF could be backfilled and sealed when disposal was complete (about 2120).

103. The cost of scenario 3 would be about £4.8 billion (discounted), which is £600 million higher than the cost of the baseline programme of £4.2 billion (discounted).