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CoRWM Position Paper: Deep Borehole Disposal

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This Position Paper reflects the Committee on Radioactive Waste Management (CoRWM) current position on the potential use of deep boreholes for the disposal of solid radioactive waste. This is to be presented against the current state of knowledge.

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1. Introduction

The potential use of deep boreholes for the disposal of solid radioactive waste has been considered for more than 40 years[1] though it has not as yet been undertaken anywhere. Recently, several stakeholder responses have referred to the possibility of using disposal in deep boreholes to contribute to the disposal of the UK radioactive waste inventory. This paper seeks to present the deep borehole option against the current state of knowledge. Before that, it is worth considering the 'state of play' that was arrived at by CORWM 1 in 2005.

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2. Deep Borehole Disposal - CoRWM 1

There are at least 20 references to borehole disposal in papers in the CoRWM archive. Most are comments along the line that 'some stakeholders think this option should be examined'. The option was indeed adopted for study, and most subsequent mentions are centred round the need to keep the technology of this option under review.

The most useful CoRWM 1 document is Paper 1078 *Deep borehole disposal for HLW, spent fuel, Pu/U,* the 'Summary' Section is given below:

> ***CoRWM Paper 1078 CoRWM Option Descriptions Version 4***
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> ***Deep borehole disposal for HLW, spent fuel, Pu/U***
>
> ***Summary***
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> This option has been considered by several countries but never proposed for implementation. Whilst liquid wastes have been injected in boreholes in Russia, this

[1] Chapman, NA 2019 Who Might Be Interested in a Deep Borehole Disposal Facility for Their Radioactive Waste? Energies 12(8):1542 · April 2019 13pp DOI: 10.3390/en12081542.

practice is no longer favoured, and deep borehole emplacement is now only considered suitable for solid radioactive waste.

In the reference option, solid waste in containers would be placed in boreholes drilled from the surface to depths of several kilometres, with diameters of less than one metre. Containers would be stacked one on top of another and separated by a layer of bentonite or cement.

Other variants have also been proposed where wastes are not cooled prior to disposal and the decay heat is allowed to melt the surrounding rock, thereby entombing the wastes when cooling occurs. It has also been suggested that wastes could be disposed of in redundant oil and gas wells.

This is an extremely expensive option requiring a large number of boreholes and as such is only considered viable for relatively small volumes of waste. It could be suitable in the UK for disposal of HLW, plutonium and/or uranium, but probably not spent fuel.

In support of CoRWM 1's deliberations they commissioned Enviros[2] to prepare summaries of their short listed options and Nirex[3] produced a technical note on CoRWM's shortlisted disposal options both of which include an examination of deep borehole disposal. They outline the potential applicability of deep borehole disposal as well as identifying the main difficulties in implementing this approach, which include many of those listed below, but in particular the fact that drilling technology was then[2] not sufficiently developed to drill boreholes of sufficient diameter to suitable depths.

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3. Deep Borehole Disposal – More Recent Developments

The CoRWM 1 material is relatively low key in its assessment of possible roles for Borehole Disposal in the UK, largely because of the sheer volume of the UK waste inventory, even back in 2005. The treatment does however point to the possible role of technology improvements in the possible widening of its applicability, so this position paper has been prepared to give a high level overview of the current state of the art and CoRWM's opinion on its potential use in the UK for radioactive waste disposal.

In 2017, RWM published a review of the alternative options for radioactive waste management that were short-listed by CoRWM in 2006[4]. This review was limited to the alternatives that were short-listed by CoRWM, together with those options that CoRWM explicitly recommended should be the subject of an ongoing review of developments and was an objective technical review of published literature. This review identifies similar issues and draws similar conclusions to those highlighted below.

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[2] Richardson, P; Thompson, G and Miller, W 2005 Summary Descriptions of CoRWMs Shortlisted Options. Enviros report to CoRWM (CoRWM Doc 1420).

[3] Nirex 2005 Summary Note for CoRWM Providing Additional Information on CoRWM's Short-listed Options TECHNICAL NOTE October 2005 Number: 487568 (CoRWM Doc 1860).

[4] RWM 2017 Geological Disposal - Review of Alternative Radioactive Waste Management Options. NDA Report no. NDA/RWM/146.

4. CoRWM's view on the current potential for the use of deep borehole disposal in the UK

On the face of it, deep borehole disposal of higher activity wastes, including plutonium, vitrified HLW and perhaps spent fuel, appears to be an attractive proposition because it would put the materials permanently out of reach. There are, however, a number of issues that are likely to be difficult to resolve that make deep borehole disposal potentially problematic. These include:

- Borehole diameter;
- Borehole stability;
- Retrieval of waste packages in failed disposal situations;
- Borehole sealing;
- Inventory size;
- Waste package size;
- Use of existing deep boreholes.

These are explored in more detail below.

Borehole Diameter

Deep boreholes several kilometres deep of sufficient diameter, of the order of 1m at disposal depth, are currently unproven technology. Shallow boreholes of this size have been drilled and it is also possible to construct shafts of larger diameter for mining purposes but not to sufficient depth for deep borehole disposal. There are significant challenges that require overcoming in order to drill boreholes of sufficient diameter and to suitable depths and these are likely to be costly and time consuming.

Borehole stability

Many rock types at depths of several kilometres would be potentially suitable for disposal but the stability of boreholes through overlying rocks would need to be ensured in order to be able to use them. For stability boreholes need to be cased through much of their length. This is the insertion of a steel or plastic pipe into the borehole to support the sides which is often grouted into position for strength. When poor ground conditions are met borehole size needs to be reduced to continue drilling beyond a fixed casing. In the hydrocarbon industry it is not uncommon for several such size reductions to occur before a reservoir is reached with a resulting reduction in borehole diameter each time in order to accommodate the casing. To attain a borehole of about 1 metre in diameter at, say 5km depth, the starting diameter is likely to be significantly larger. The weight of the large diameter casing strings will make their handling and emplacement very difficult.

Retrieval of waste packages in failed disposal situations

If a waste package being emplaced in a borehole becomes wedged at a depth above that considered suitable for disposal during emplacement, it will need to be retrieved. Depending on depth and ground conditions recovery of any such packages is likely to be problematic and costly.

Borehole sealing

Sealing of waste packages in boreholes at depth is currently untested and may be difficult or impossible to validate. Depending on their depth and method of installation the presence of casing(s) within a borehole may make borehole sealing hard to achieve they may also provide a pathway for the future migration of radionuclides to the near surface or surface environments.

Inventory size

The UK has a large and varied inventory of radioactive waste destined for eventual disposal. Deep borehole disposal will never be suitable for large waste packages, including, for example, intact submarine reactors, nor will it be cost effective for ILW, any longer-lived LLW destined for deep disposal, depleted uranium etc.

Waste package size

Attaining deep boreholes of 1m or more in diameter will be technically challenging and it is more likely that diameters of up to 50cm will be more practical. This limits the size of waste packages that can be emplaced in the borehole and would exclude the UK's inventory of vitrified HLW in its current form as well as many other wastes.

Use of existing deep boreholes

Existing hydrocarbon wells are not of sufficient diameter for solid waste disposal and would be expensive to enlarge because the casing would need to be drilled out (it is grouted into place). It would also mean disposal into a known economic resource. In the case of boreholes used for shale gas exploration or exploitation the deployment of hydrofracking technologies during their development will have disturbed the potential host rock formations reducing their suitability for radioactive waste emplacement.

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5. Conclusions

The use of deep boreholes for the disposal of the UK's radioactive waste is unlikely to be practical for a number of reasons including the size and range of wastes in the inventory, the size of packaging and the as yet unproven practicalities of drilling boreholes of sufficient diameter to appropriate depths. As Chapman[1] points out they may be a suitable option for countries with smaller inventories of more limited waste types.

While they may not be a practical option for the majority of the UK's waste inventory, it may be appropriate to consider the use of deep boreholes as an option, from a technical perspective, for the disposal of certain materials, such as plutonium and high enriched uranium (if these materials are declared waste) or some spent fuels where achieving total isolation without prospect of retrieval is an important aim. Such consideration would need to be subject to assessments of cost, specificity of waste type, physical integrity, groundwater context and regulatory considerations. If such boreholes were drilled into rocks deep below the facility from an already constructed GDF then many of the problems outlined above remain but their impacts, if they occur, are reduced. The construction and operation of a suitable drilling rig within a purpose built part of a GDF will be challenging and likely to be costly but would have the advantage of ensuring that specific parts of the inventory are irretrievable.
