NIREX

PE/NRX/13/S1

Appellant Ref: DB/CD 8.5.1
LPA Ref: 4/94/9011
DOE Ref: APP/HO900/A/94/247019

UNITED KINGDOM NIREX LIMITED

Rock Characterisation Facility

Longlands Farm, Gosforth, Cumbria

SUPPLEMENTARY PROOF OF EVIDENCE

OF

Dr J HOLMES

MA, MBA, PhD, CEng, FInstE, MIM

SCIENCE OVERVIEW

CONTENTS

Back to NRX13 Menu Back to POE Menu Back to Homepage

1. SUMMARY

Introduction

1.1 This Supplementary Proof of Evidence addresses two main areas:

(i) the scientific case for the RCF (Section 3); and

(ii) miscellaneous issues raised in Objectors' Proofs of Evidence or in cross-examination of Mr Folger (Section 4).

The Scientific Case for the RCF

1.2 There appears to be a consensus between Nirex and the Objectors that a stage of underground investigations is required in order to evaluate fully the potential of a site to host a deep repository for radioactive waste.

1.3 The Objectors advance two main strands of argument for not granting planning permission for the RCF at Sellafield:

- Sellafield is a 'poor site' and hence there is no point in proceeding with the RCF and investigations should be transferred to one or more alternative sites; and
- development of the RCF at Sellafield is premature as further work is required, including establishment of baseline conditions, prior to RCF construction.

1.4 Nirex's position is that the site holds good promise as a potentially suitable location for a repository and that it is appropriate to develop the RCF now.

1.5 In respect of 'good promise', a substantial base of information on the characteristics of the site has been established. However, the suitability or otherwise of a site cannot be established on the basis of review of individual characteristics in isolation. Nor can it be established on the basis of a comparison of whether or not a site meets descriptions of generic environments used to assist in site sieving during the site identification phase. It is the evaluation of the overall post-closure safety performance of a repository at a site which determines the suitability or otherwise of a site.

1.6 The post-closure safety performance of a repository at Sellafield has been evaluated in *Nirex 95* [COR/522] which indicates results consistent with regulatory requirements. Site characterisation data coming forward since those which comprised the basis for *Nirex 95* have broadly confirmed its basis, but there are some indications that it may have been conservative in its representation of networks of connected fractures in the BVG and between the BVG and the overlying sandstones above the North Head Member of the St Bees Sandstone.

1.7 I consider that now is the appropriate time to develop the RCF for the following reasons:

- baseline conditions have been established;
- our understanding of the site has reached a sufficient level of development and the necessary scientific tools are available; and
- further work to be carried out in parallel with the RCF is unlikely to change our view of site performance substantially.

1.8 Confidence in our evaluation of the performance of a repository at Sellafield is not yet sufficient to underpin a decision on whether or not to propose development of repository. The RCF is the essential next step to reach that decision point. There is no reason not to proceed with the RCF given that baseline conditions have been established, and that science and our understanding of the site are sufficiently advanced to ensure the RCF will take our confidence forward. The Royal Society Study Group, the RWMAC and the Nirex Review Panel have similarly concluded that the RCF is an appropriate, timely and essential next step in our programme. Other deep waste repository programmes round the world plan for a similar stage of underground investigations in order to establish the suitability of sites for a repository.

Miscellaneous Issues

1.9 In Section 4 I address four issues raised in Objectors' Proofs of Evidence or in cross-examination of Mr Folger as follows:

(i) Peer review: by reference to Mr Folger's evidence I summarise the way in which peer review will inform the Nirex Science Programme;

(ii) Royal Society Study: I present the Nirex response to the Royal Society Group's main recommendations;

(iii) Uniqueness: by comparison with other programmes I establish that it is inappropriate to label either the RCF or the Nirex repository programme as unique; and

(iv) Scientific Approach: I address issues raised by Friends of the Earth and Greenpeace on Nirex's scientific approach.

2. INTRODUCTION

2.1 This Supplementary Proof of Evidence addresses two main areas:

(i) the scientific case for the RCF (Section 3); and

(ii) miscellaneous issues raised in Objectors' Proofs of Evidence or in cross-examination of Mr Folger (Section 4).

2.2 Section 3 identifies the consensus on the need for a stage of underground investigations to evaluate fully the potential of a site to host a deep repository and summarises the reasons given by the Objectors for not granting planning permission for the RCF. It then goes on to summarise Nirex's scientific case for the RCF and, in particular, that the site holds good promise for a deep repository and that now is the appropriate time for development of the RCF.

2.3 Section 4 addresses four issues as follows:

- peer review;
- Royal Society Study;
- uniqueness; and
- scientific approach.

3. THE SCIENTIFIC CASE FOR THE RCF

3.1 This Section summarises Nirex's scientific case for the RCF in response to that made by the Objectors against it, as follows:

- the consensus on the need for a stage of underground investigations to evaluate fully the potential of a site to host a deep repository for radioactive waste (paragraphs 3.2 to 3.4);
- the scientific case made by the Objectors against the RCF at Sellafield (paragraph 3.5 to 3.10);
- the scientific case for the RCF in respect of the good promise that Sellafield has as a potentially suitable location for a repository (paragraphs 3.11 to 3.23);
- the scientific case for the RCF in respect of now being the appropriate time for its development (paragraphs 3.24 to 3.30); and
- conclusions (paragraphs 3.31 to 3.33).

Consensus on the Need for Underground Investigations

3.2 There appears to be a consensus between Nirex and the Objectors that a stage of underground investigations is required in order to evaluate fully the potential of a site to host a deep repository for radioactive waste. Thus, for example, at paragraph 1.4 of his Proof of Evidence (PE/CCC/7) Mr Hetherington indicates:

> "*The County Council, of course, accepts that in-situ characterisation of a chosen site is necessary before final regulatory approval*".

At paragraph 4.20 of PE/CCC/7 Mr Hetherington indicates:

> "*The hydrogeological and safety case evidence we have put forward suggests that now is the time to fully review the Sellafield option. It is in this context that the RWMAC support for the RCF as a whole must be judged. In effect the Council accepts their overall approach, 'in simple terms, the more information, the better.*"

3.3 Similarly, Dr Green and DrWestern for Friends of the Earth indicate (PE/FOE/1, paragraph 9.5):

> "*Within the staged development of a nuclear waste repository construction of a rock characterisation facility will be required. However, it is critically important that RCF construction is not undertaken prematurely.*"

3.4 Dr Haszeldine for Greenpeace indicates (PE/GNP/3, paragraph 16.10):

> "*I have no objection to the principle of a Rock Laboratory in the UK. However the choice of the present site appears premature, ...*"

The Scientific Case of the Objectors Against the RCF

3.5 The Objectors advance two main strands of argument for not granting planning permission for the RCF at Sellafield:

- Sellafield is a 'poor site' and hence there is no point in proceeding with the RCF and investigations should be transferred to one or more alternative sites; and
- development of the RCF at Sellafield is premature as further work is required, including establishment of baseline conditions, prior to RCF construction.

I will deal with each of these in turn.

Poor Site

3.6 It is primarily Cumbria County Council and, in particular, Professor Mather, Dr Starmer and Mr Hetherington who develop the argument that an RCF should not be developed at Sellafield because it is a "*poor site*". Professor Mather lists a series of "*negative characteristics*" of the groundwater regime at paragraph 8.7 of his Proof of Evidence (PE/CCC/4), points to "*the complexity and unpredictability of the hydrogeology*" at paragraph 8.9, and concludes at paragraph 8.10, "*The evidence so far collected reinforces the conclusion that this is a poor site*". Thus Professor Mather bases his "*poor site*" conclusion on hydrogeological characteristics rather than an evaluation of post-closure safety performance of a repository.

3.7 Dr Starmer does consider post-closure safety performance and concludes at paragraph 7.9 of his Proof of Evidence (PE/CCC/5) that "..... *the current performance assessment is not robust*", and that, "..... *no amount of further investigation or improvements in models will guarantee improved results that will unequivocally meet the risk target*".

3.8 Mr Hetherington, on the basis of the conclusions of Professor Mather and Dr Starmer, draws a somewhat firmer conclusion that "*.... it is already evident that the Sellafield site is not suitable for the use proposed (a repository) and that Nirex, rather than proceeding with the RCF now, should take time to revisit and re-evaluate a site or sites which are likely to lower radiological risk and provide greater levels of confidence in their assessment.*" (PE/CCC/7, paragraph 2.5). Mr Hetherington does not indicate whether his conclusion that Sellafield is not suitable means that he considers that the site will not meet regulatory requirements. Nirex has previously acknowledged that sites offering lower radiological risk could potentially exist (**PE/NRX/12/S1**, paragraphs 6.4 and 6.5).

3.9 Dr Haszeldine for Greenpeace expresses reservations about the suitability of the site, and in particular at paragraph 16.6 of PE/GNP/3, "*This is arguably one of the most geologically difficult sites in the UK on*

which to construct a Repository for radioactive waste." However, he does not appear to rule the site out, given his comments at paragraph 16.10 (PE/GNP/3) on the need for more information at Sellafield.

Prematurity

3.10 It is primarily Friends of the Earth and Greenpeace who develop the line of argument that development of the RCF at Sellafield is premature. Dr Green and Dr Western for Friends of the Earth conclude (PE/FOE/1, paragraph 10.6):

> "*FOE concludes that, because of the large volume of further necessary work before Nirex should commence on upon* [sic]*RCF construction, the length of time that this essential work will take, and the lack of a properly validated baseline model of existing conditions on the site, planning permission should not be granted*".

Dr Richardson for Greenpeace indicates (PE/GNP/4, paragraph 11.3):

> "*In international terms the site characterisation role of RCF is premature, since laboratories have not yet demonstrated that adequate predictions in fractured rock can be made*".

The Scientific Case for the RCF: Good Promise

3.11 Dr Chaplow and Dr Hooper in their Main and Supplementary Proofs of Evidence (**PE/NRX/14**, **PE/NRX/14/S1** and **PE/NRX/15**, **PE/NRX/15/S1** respectively) have presented the basis for Nirex's conclusion that Sellafield holds goods promise as a potentially suitable location for a repository. That basis is summarised in paragraphs 3.12 to 3.23 below.

3.12 Results from the extensive programme of investigations that has been carried out since 1989 show that the characteristics of the site are broadly as envisaged in 1989 when the site was selected for detailed geological investigations, but that we now have a much more detailed picture of the site than then existed. The results indicate that the flow of groundwater through the potential repository host rock, the BVG, is low and that, in contrast, there is high flow towards the sea in the upper parts of the overlying sedimentary rocks. These characteristics enable the geological setting at Sellafield to perform the two key functions identified as necessary at paragraph 4.6 of my Proof of Evidence (**PE/NRX/13**) to ensure the satisfactory operation of the physical and chemical barriers of the repository, and to ensure sufficient dilution of residual radionuclides released from the repository vaults.

3.13 Although many radionuclides can be contained within a repository until they have decayed to insignificant levels, in the long term some releases of long-lived radionuclides will inevitably occur. Retardation and dilution in the geological environment are then the active mechanisms whereby the concentrations of these radionuclides and their consequent radiological impacts are reduced. For mobile and long-lived radionuclides which do not appear to interact strongly with the rock such as chlorine36 and iodine-129, dilution is the most important process.

3.14 That dilution has an important role to play in ensuring post-closure safety was recognised at paragraph 3.2.8 of *Nirex Report No. 71. Deep Repository Project, Preliminary Environmental & Radiological Assessment and Preliminary Safety Report* ("*PERA*") [COR/501]:

> "*Dispersal, dilution and radioactive decay with time during radionuclide migration through the geosphere provide additional mechanistic barriers*".

Similar conclusions have been reached in the Swiss programme to develop a high-level waste repository (NRX/13/3, page 81):

> "*Although it is not normally regarded as a safety barrier, the importance of the contrast between the low water flux through the low-permeability basement and the much higher fluxes in major water-conducting faults, higher-permeability crystalline basement, overlying sediments, gravel*

aquifers and surface waters, should be emphasised. Dilution along the flow path considerably decreases the concentration of any released radionuclides and hence also their potential hazard".

3.15 The European Commission recommended criteria for siting a repository also recognise the role to be played by dilution (FOE/7/14, page 6):

> "*Because water is the most effective natural carrier of radioactivity out of the repository, low groundwater flow and/or appropriate dilution capabilities are essential requirements, together with appropriate characteristics of the underground waters*".

3.16 It is not, however, the hydrogeological characteristics of a site in isolation that form the basis for judging the suitability or otherwise of a site, but the evaluation of the post-closure safety performance of a repository at the site. This is discussed at paragraphs 6.24 to 6.28 of Mr Folger's Supplementary Proof of Evidence (**PE/NRX/12/S1**).

3.17 Potential repository performance in respect of the groundwater pathway, given our understanding of the site in early 1994 has therefore been evaluated in *Nirex 95: A Preliminary Analysis of the Groundwater Pathway for a Deep Repository at Sellafield* ("*Nirex 95*") [COR/522]. The analysis of repository performance at Sellafield, presented in *Nirex 95* incorporates uncertainties in the evaluation of risk in a manner consistent with regulatory requirements. Conservative, simplifying assumptions have been used where current understanding does not permit more detailed description of the mechanisms and processes to be incorporated with confidence. The analysis specifically includes features of the site identified by Objectors as "*negative characteristics*" for example, the potential for hydraulic connection over extended distances within the BVG and between the BVG and overlying sandstones (the Type II features).

3.18 *Nirex 95* [COR/522] presents a base case in which calculated risks for terrestrial discharge in the boreal biosphere are 1.1×10^{-7} at twenty thousand years and 3.3×10^{-7} at four million years. For the agricultural well, a peak annual risk of 1.7×10^{-6} is indicated on the basis of preliminary calculations. The potential over-estimation of risk from the agricultural well in these calculations due to the neglect of dilution by recent meteoric water is discussed at page 6.19 of Volume 3 of *Nirex 95* [COR/522]. Dr Hooper's Proof of Evidence (**PE/NRX/15**, at paragraph 5.39) points to design measures that could be taken to reduce risks if necessary. It is considered that these factors should lead to values of calculated risk below the target in future evaluations.

3.19 It is recognised that the assessment models used in *Nirex 95* [COR/522] do not fully reproduce the elevated heads at depth. Also, information from the Site Characterisation Programme arising subsequent to that which forms the basis for *Nirex 95* [COR/522] suggests that the extent of hydraulic connections within the BVG, and to the overlying sandstones above the North Head Member of the St Bees Sandstone, may have been overestimated (**PE/NRX/14**, paragraph 6.70, vi and vii; **PE/NRX/14/S1**, paragraphs 8.29 to 8.34). Variant calculations are included in *Nirex 95* [COR/522, Section 7] which evaluate the consequences for risk of these various effects. These calculations show that risk is relatively insensitive to the variants considered. This insensitivity lends confidence to the robustness of our evaluation and arises from the characteristics of the site, in particular the low permeability of the basement rock and the potential for dilution in the overlying aquifer. The factors controlling repository performance at Sellafield are discussed in more detail in Section 8 of Volume 3 of *Nirex 95* [COR/522].

3.20 The results presented in *Nirex 95* [COR/522] reflect a number of assumptions which it is considered may in due course prove to be unduly conservative. Work is in progress to address the basis for these current assumptions which may lead to revised models whose incorporation in future assessments will tend to lower calculated risk. Dr Hooper's evidence identifies, in particular, the following assumptions:

- Unrestricted access of groundwater to the wastes immediately after repository closure in the base case (Nirex 95, Volume 3, Sub-section 3.3.1(a), page 3.7) [COR/522]. This has the effect of assuming complete and instantaneous dissolution in groundwater of the entire inventory of chlorine-36 and iodine129. It ignores the mechanisms that would in reality spread the release of these radionuclides to groundwater over many thousands of years (and therefore reduce peak risk) including container corrosion, diffusion through waste encapsulation materials and corrosion of metals and ceramics where these incorporate part of the inventory;

- Release of radionuclides from repository vaults to Type II features (Nirex 95, Volume 3, Sub-section 3.2.4, page 3.5) [COR/522] which is the shortest route across the BVG. This ignores potential benefits of avoiding intersections of vaults with Type II features or sealing Type II features;
- Absence of mineralisation as a mechanism for reducing the solubility and hence the release of uranium238 in particular (**PE/NRX/15**, paragraph 5.49);
- Reduced sorption in the near field to make allowance for possible long-term deleterious mechanisms (**PE/NRX/15**, paragraph 5.23). This leads to higher calculated releases of radionuclides than are suggested by results of research work on long-term effects (**PE/NRX/15/S1**, paragraph 6.32); and;
- A depth of the agricultural well consistent with the maximum identified from practice in the area, ignoring the likelihood of shallower wells due to their interception of adequate water supply at lesser depth (**PE/NRX/15/S1**, paragraph 8.33 and Nirex 95, Volume 3, pages 6.18 to 6.20) [COR/522] and the absence of mixing of recent meteoric water and sandstone aquifer water in the analysis of the agricultural well (Nirex 95, Volume 3, page 6.19) [COR/522] which would lead to reductions in calculated risks.

3.21 *Nirex 95* [COR/522] addresses the most important pathway in radiological terms, the groundwater pathway, but does not cover all pathways for radionuclide return to the human environment. Similarly, it does not address all processes, e.g. mobilisation of radionuclides by colloids or transient effects due to climate change, which could, in principle, influence calculated risk. It is planned that, through the RCF and other components of the Science Programme that will be carried out in parallel, we will move to a position where the safety assessments that underpin the two key decision points identified at paragraph 6.21 of my Proof of Evidence (**PE/NRX/13**) (i.e. a decision by Nirex to propose development of a repository, and a decision by the regulatory authorities to approve the start of disposal operations) will address all the factors influencing the post-closure safety performance of the repository.

3.22 Consideration has been given to alternative pathways as summarised in Dr Hooper's Proof of Evidence (**PE/NRX/15**, paragraphs 5.41 to 5.45), and effects such as the impact of colloids on radionuclide transport or of transient effects associated with climate change (see **PE/NRX/15/S1**, paragraphs 7.52 to 7.58 (colloids), and paragraphs 8.7 and 9.67 to 9.70 (climate change)). This consideration has not identified pathways or processes not yet incorporated in our assessments which are likely to change significantly our conclusions in respect of repository performance. Further work in the RCF, and carried out in parallel with the RCF, will enable these pathways and processes to be incorporated in the assessments underpinning future decision points.

3.23 For the groundwater pathway we recognise a number of factors which could influence the calculated value of risk in future assessments:

(i) as modelling and understanding advance, we will incorporate more accurate descriptions of processes within the assessment modelling and therefore be able to modify assumptions including those conservative assumptions that are currently acting to over-estimate calculated risks;

(ii) incorporation of models which reflect more recent information on hydraulic connections within the BVG, and to the overlying sandstones, and which more closely reproduce pressure and salinity distributions at the site; and

(iii) potential benefits arising from optimisation of repository design and in particular the depth, location, layout and orientation of the disposal vaults within the host rock.

The Scientific Case for the RCF : Timing

3.24 I consider that it is appropriate to develop the RCF now for the following reasons:

- baseline conditions have been established;
- our understanding of the site has reached a sufficient level of development and the necessary scientific tools are available; and
- further work to be carried out in parallel with the RCF is unlikely to change our view of site performance substantially.

Paragraphs 3.25 to 3.30 below provide further explanation of each of these three reasons.

3.25 Prior to construction of the RCF, baseline conditions for groundwater pressures and geochemical conditions need to be established. Sufficient information needs to have been acquired so that:

- the disturbance created by the RCF can be measured with confidence and used to test and develop models of the site; and
- there is a sufficient database on undisturbed conditions that the properties of the PRZ can be interpreted within the context of regional groundwater flow and hydrochemical models.

3.26 Dr Chaplow's Main and Supplementary Proofs of Evidence at Appendix 2 of **PE/NRX/14** and Section 10 of **PE/NRX/14/S1** describe the position which has been achieved in respect of groundwater pressures and geochemistry and provides the basis for our view that baseline conditions have been established. The RWMAC have indicated that their 1993 recommendations on the time required to establish baseline conditions are now likely to be met in view of the interpolation into the programme of the RCF planning inquiry [GOV/414, paragraph 14]. As explained by Dr Chaplow (**PE/NRX/14/S1**, paragraphs 10.36 to 10.39), where further geochemical data are needed, they can most appropriately be obtained from the RCF, or from further boreholes (for example, Boreholes 15 to 18).

3.27 Substantial progress has been made over the last 10 years in characterising flow in fractured rocks, much of it in radioactive waste programmes with which Nirex is closely involved. Also, through appropriate treatment of uncertainty, the appropriate use of stochastic and deterministic descriptions, and use of conservative, simplifying assumptions to ensure that we have not underestimated risk, we do not need a comprehensive understanding and description of all features and processes. Given these considerations, it is our view that the necessary scientific tools are available, in particular in respect of flow in fractured rocks, to ensure that the RCF can advance our confidence in the safety assessment. Dr Hooper's Supplementary Proof of Evidence at paragraphs 9.18 to 9.27 (**PE/NRX/15/S1**) describes the stage of development of fracture flow models.

3.28 It is notable that the Royal Society Study Group considered the stage of development of the relevant fields of science and arrived at the conclusion (pages 6 and 7) [COR/605] that:

> "*Its* [the RCF's] *construction should begin as soon as is practicable, bearing in mind the need to complete some site characterisation studies in advance of the disturbance to the hydrogeological regime that building the RCF will cause.*"

My understanding is that their reservation on timing related to the need to establish baseline conditions which I have discussed at paragraphs 3.25 and 3.26 above.

3.29 Substantial progress has been made in developing a suite of models of the groundwater flow system at Sellafield. The current iteration in their development associated with the Borehole RCF3 Pump Test will permit further refinement of those models. The RCF represents the next major opportunity to take those models forward, given that it will test their capability to predict the observations of the groundwater system that will be made in the RCF and it will enable us to test our judgements on the nature of the networks of connected fractures upon which they are based.

3.30 Dr Chaplow has described the extensive programme of surface-based site characterisation that has been carried out (**PE/NRX/14**, Appendix 1). We are finding that new boreholes and new observations are adding to the detail of our understanding of the site rather than substantially changing that understanding. It is considered that remaining surface-based activities, while necessary to complete our picture, are very unlikely to substantially change our view of the site. Whereas conservatisms tending to over-estimate risk

have been recognised (paragraph 3.20), consideration of effects not included in the *Nirex 95* safety assessment [COR/522], as discussed at paragraph 3.22 above, indicate that they are unlikely to change substantially our evaluation of the safety performance of a repository at Sellafield. It is therefore appropriate that these remaining activities should be carried out in parallel with the RCF and there is no sound reason to delay the RCF to allow for the surface-based experiments to be completed.

Conclusions

3.31 I conclude that a substantial base of information on the characteristics of the site has been established. However, the suitability or otherwise of a site cannot be established on the basis of review of individual characteristics in isolation. Nor can it be established on the basis of a comparison of whether or not a site meets descriptions of generic environments used to assist in site sieving during the site identification phase. It is the evaluation of the overall post-closure safety performance of a repository at a site which determines its suitability or otherwise.

3.32 The post-closure safety performance of a repository at Sellafield has been evaluated in *Nirex 95* [COR/522] which indicates results consistent with regulatory requirements. Site characterisation data coming forward since those which comprised the basis for *Nirex 95* have broadly confirmed its basis, but there are some indications that it may have been conservative in its representation of networks of connected fractures in the BVG and between the BVG and the overlying sandstones above the North Head Member of the St Bees Sandstone.

3.33 However, confidence in our evaluation of the performance of a repository at Sellafield is not yet sufficient to underpin a decision on whether or not to propose development of repository. The RCF is the essential next step to reach that decision point. There is no reason not to proceed with the RCF given that baseline conditions have been established, and that science and our understanding of the site are sufficiently advanced to ensure the RCF will take our confidence forward. The Royal Society Study Group, the RWMAC and the Nirex Review Panel have similarly concluded that the RCF is an appropriate, timely and essential next step in our programme. Other deep waste repository programmes round the world plan for a similar stage of underground investigations in order to establish the suitability of sites for a repository.

4. MISCELLANEOUS ISSUES

4.1 In this Section I address four issues raised in Objectors' Proofs of Evidence or in cross-examination of Mr Folger, as follows:

(i) peer review;
(ii) Royal Society Study;
(iii) uniqueness; and
(iv) scientific approach

Peer Review

4.2 The need for peer review of the Nirex Science Programme is a recurrent theme raised in many of the Objectors' Proofs of Evidence. Nirex's approach to peer review and the publication of information from the Science Programme is set out in Mr Folger's Supplementary Proof of Evidence (**PE/NRX/12/S1**, paragraphs 8.1 to 8.6). He explains that peer review is an integral part of the Science Programme. Consequently, time is allowed for peer review of plans for activities and of results prior to publication. In my Proof of Evidence (**PE/NRX/13**, paragraph 5.4) I explain the quantity of information that has been published or made available for consultation to date. In his evidence to the Inquiry on Day 25, Mr Folger indicated that Nirex will publish, prior to commencement of RCF shaft sinking, predictions of significant findings expected to arise during the shaft sinking phase. Mr Folger indicates in his Proof of Evidence (**PE/NRX/12**, paragraph 9.8) that we will release results from the RCF sector by sector.

4.3 Hence, I consider that results from the Science Programme have been, and will continue to be, made available to the wider academic community and other interested groups, such that the consequent review and challenge, which complements that which is a regulatory necessity, is facilitated in a timely way. Given

that the Science Programme has at least 6 years to run prior to a decision on whether to propose repository development at Sellafield (**PE/NRX/12/S1**, paragraph 4.3), I believe that these arrangements will permit Nirex to take full advantage of such review and associated scientific debate. I therefore consider that concerns expressed by Dr Western and Dr Green in their Proof of Evidence (PE/FOE/1, paragraph 7.10) and by Mr Richardson (PE/GNP/4, paragraph 8.16) are met.

4.4 Mr Richardson indicates (PE/GNP/4, paragraph 10.7) that Nirex's provisional plan for a decision on a repository planning application at the end of Phase 1 "*flies in the face of all accepted scientific practice*" in that it "*does not allow for any independent peer review*". As I indicate at paragraph 4.2 above, peer review is an integral part of the Science Programme and will take place continuously through Phase 1 of the RCF. Also, given that Nirex will publish in advance its predictions of significant findings expected to arise during shaft sinking and results will be published on a sector by sector basis throughout Phase 1, I consider that there is also opportunity for review by the wider academic community and other interested groups. Initially that review will inform Nirex's decision on whether to propose repository development, and subsequently it will inform the Public Inquiry into a repository planning application which it is assumed, in Nirex's contingent programme, will not commence until a year after completion of the RCF Phase 1 science programme.

Royal Society Study

4.5 *The Royal Society Study Group Report* [COR/605] is referred to by a number of Objectors in their Proofs of Evidence. The Royal Society Study was carried out during the latter part of 1993 and the first half of 1994, following an invitation to the Royal Society from Nirex. The Terms of Reference of the Study are set out at Section 2.2, page 13 of the Study Group's report [COR/605]. As indicated at Section 2.3 of [COR/605], while the Study was to be concerned with the development of generic guidelines;

> "*... the Group depended largely upon studying the actual conduct of the work on the proposed deep repository at Sellafield in order to be able to address Item 2* [appropriate methods for the treatment of fundamental uncertainties] *of the above Terms of Reference.*"

The Royal Society Study Group Report [COR/605] indicates at page 15 that Appendix E lists the "*bibliographic references used in the preparation of this Report*". The Nirex response to the Report, and in particular the six main recommendations set out at pages 10 and 11 was issued in November 1994 and is attached as Appendix 1.

Uniqueness

4.7 Questions were put to Mr Folger in cross-examination on the extent to which the RCF and the Nirex repository project could be considered unique. Comparisons between the Nirex project and those in other countries are made in my Proof of Evidence (**PE/NRX/13**, paragraphs 8.1 to 8.3 and at Table 8.1). I conclude there that the proposal to carry out a stage of underground investigations in an RCF at Sellafield, prior to a decision on whether to propose development of a repository, is consistent with general practice internationally.

4.8 In addition to the comparisons made at Section 8 of my Proof of Evidence (**PE/NRX/13**), I would make the following comparisons:

- most new laboratories proposed in other countries are site-specific rather than generic laboratories;
- Finland, France and the United States are proceeding straight to rock characterisation facilities and then repositories without first building and operating generic laboratories;
- it is planned in Sweden that a deep waste repository will be operational in saturated fractured rock for long-lived wastes by the year 2010, i.e. in advance of the planning date for the Nirex repository, and detailed investigations have not yet commenced at a candidate site;
- deep waste repositories for long-lived intermediate level wastes are planned to be operational by 2000 in Konrad, in Germany, and WIPP in the United States. In both cases, safety assessments have been submitted to the appropriate authorities.

4.9 Whilst the application of sufficient qualifiers will inevitably result in uniqueness, particularly for a relatively small sample as in the case of deep waste repository projects, I consider that there are sufficient similarities between Nirex's plans and those in other countries that it is inappropriate to label either the RCF or the Nirex repository programme as unique.

Scientific Approach

4.10 Dr Green and Dr Western at paragraph 7.3 of their Proof of Evidence (PE/FOE/1) point to paragraph 50 of the *Review of Radioactive Waste Management Policy, Final Conclusions* ("*The 1995 White Paper*") [GOV/208] and in particular to one of the supporting principles of sustainable development that "*decisions should be based on the best possible scientific information and analysis of risks*". At paragraph 10.4 of PE/FOE/1 they set out five reasons why they do not consider the scientific information obtained so far in the Nirex Science Programme as being the "*best possible*". These specific points raised by Dr Green and Dr Western have been addressed at:

bullet1:	PE/NRX/14/S1	paragraphs 8.89 to 8.102
bullet2:	PE/NRX/14	Appendix 2
bullet3:	PE/NRX/14/S1	Section 10
	PE/NRX/15/S1	paragraphs 10.20 to 10.26, Appendix A1 to A3, paragraphs 6.27 to 6.94
	PE/NRX/15/S1	paragraph 6.30
bullet4:	PE/NRX/15/S1	paragraphs 7.103 to 7.104, Section 10, Appendix 1.
bullet5:	PE/NRX/12/S1	paragraphs 8.1 to 8.6
	PE/NRX/13	paragraphs 5.2 to 5.4

I therefore do not accept the basis for their assertion

4.11 More generally, I have set out at paragraphs 5.1 to 5.6 of my Proof of Evidence (**PE/NRX/13**) the approach taken by Nirex to the Science Programme and, at paragraphs 5.5 and 5.6, the praise from the RWMAC and the Royal Society for the quality of information arising from the programme. An important aspect of our approach is to ensure long-term involvement of contractors of international repute. Table 4.1 lists eight of the main contractors who have a major and long-term involvement in the programme. I consider that the Nirex Science Programme to date, and that planned for the future, of which the RCF is an essential component, is consistent with generating the "*best possible scientific information*" indicated at paragraph 50 of the *1995 White Paper* [GOV/208].

4.12 Dr Haszeldine at paragraph 15.2 of his Proof of Evidence (PE/GNP/3) indicates that he is "*very impressed with the quality and validity of Nirex data.*" He indicates that "*I have only praise for the integrity and generosity of individual scientists from Nirex and its Contractors whom I have collaborated with*". However, he indicates at paragraph 15.1 that he has concerns that "*major misconceptions in basic judgements are being propagated through the Nirex system, and are being undetected by the Nirex system of Quality Assurance (QA). This concern has been shown by the ability of a few University scientists to assemble radically alternative views of the same area, on the same data, to those proposed by Nirex*." The Supplementary Proofs of Evidence of Dr Hooper and Dr Chaplow have established that the "*radically alternative views of the same area*" assembled by "*a few University scientists*" (PE/GNP/3, paragraph 15.1) (by which I presume Dr Haszeldine means those University scientists such as himself who have contributed Proofs of Evidence to the Objectors' cases) are not well founded.

5. REFERENCES

GOV/208
Review of Radioactive Waste Management Policy. Final Conclusions. July 1995.

GOV/414
Review of aspects of the scientific mission and role of the Nirex Rock Characterisation Facility at Sellafield. The Radioactive Waste Management Advisory Committee. September 1995.

COR/501
Nirex Report 71, Deep Repository Project - Preliminary Environmental and Radiological Assessment and Preliminary Safety Report, 1989.

COR/522
Nirex Science Report S/95/012, Post-closure Performance Assessment, Nirex 95: A Preliminary Analysis of the Groundwater Pathway for a Deep Repository at Sellafield, July 1995.

COR/605
The Royal Society, Disposal of Radioactive Wastes in Deep Repositories, November 1994.

NRX/13/3
NAGRA Technical Report 93-09E, Kristallin-1, "Conclusions from the regional investigation programme for siting a HLW repository in the crystalline basement of Northern Switzerland", May 1994.

FOE/7/14
EUR 14598 Euradwaste Series No 6 Radioactive waste disposal: recommended criteria for siting a repository. Commission of the European Communities, 1992.

Table 4.1 : Main Contractors Involved in the Nirex Science Programme

Organisation	Involvement in the Nirex Science Programme	Experience of Other Radioactive Waste Programmes
AEA Technology	NSARP and safety assessment programmes	Major investigations into radioactive waste disposal for Department of the Environement (UK), SKB (Sweden), Nagra (Switzerland), JNFL (Japan), PNC (Japan), GRS (Germany), KAERI (Japan
British Geological Survey	Geological interpretation, core and mineralogical characterisation, hydrogeological modelling	Nagra, SKB, AECL (Canada)
Entec Hydrotechnica	Hyrdogeological characterisation and modelling	
Geoscience	Design, specification and supervision of geological investigations and geological interpretation	SKB, AECL, Nagra
Sir Alexander Gibb and Partners	Geotechnical engineering and earth sciences	Characterisation of 13 proposed radioactive waste disposal sites
Golder Associates	Interpretation of hydrogeological testing and hydrogeological modelling	US DOE, PNC BFS (Germany), ENRESA (Spain), SKB
KSW Deep Exploration Group	Site investigation services	Nagra and UK shallow site programme
Wimpey International	Geochemistry	

APPENDIX 1

ROYAL SOCIETY STUDY GROUP REPORT

ON THE SCIENCE OF RADIOACTIVE WASTE DISPOSAL:

INITIAL NIREX RESPONSE

Nirex approached the Royal Society in the spring of 1993 to ask if it would set up an independent Study Group to address the scientific issues associated with the evaluation of the performance over long timescales of an underground repository for radioactive wastes. This approach was prompted by the Company's desire to ensure that the Nirex Scientific Programme, currently focused on evaluation of the suitability of a site at Sellafield for a deep repository, is subjected to high quality challenge and review. In line with Nirex's policy of openness in respect of its work, the Company recognised it as important that the Study Group's conclusions be made public and that the Group should be completely independent. The Company is grateful to the Royal Society for responding positively to the initial approach, and to the Study Group members for all their efforts in assimilating and drawing together a coherent set of conclusions in a limited period of time. Nirex believes that the Study Group has made an important contribution to public discussion of the science of radioactive waste disposal and welcomes publication of the Report.

Given the remit of the Study Group to examine the Nirex Scientific Programme in the context of 'international best practice', Nirex is pleased to note the conclusions drawn about the quality of Nirex's scientific work and the high respect which it commands from others engaged in parallel work worldwide. Also welcome is the firm endorsement of the need to proceed with the Rock Characterisation Facility (RCF), the next major step in Nirex's programme to characterise the Sellafield site.

One objective in setting up the Study was to identify areas in which the Nirex programme could be strengthened. The Study Group's recommendations in this respect are therefore particularly useful and in many cases work is already in hand, or planned, to address the issues raised by the Study Group.

The initial Nirex response addresses the six principal recommendations made by the Study Group as follows:

1. With respect to the timetable of the programme, Nirex well accepts the need to respect the stage of development of the science and the need to expose key issues of interpretation to review and scientific debate in advance of a public inquiry into a repository. In fact, such factors are key elements in Nirex's forward planning, which sets tight targets to maintain momentum and cost-effectiveness but provides scope to take more time to resolve particular issues as necessary. The Study Group has recognised Nirex's track record of flexibility.

   The timescales for the Nirex project are in line with those being pursued by some other countries (e.g. Sweden, US and Germany all plan to have a deep repository for long-lived wastes operational by 2010). Inevitably there are uncertainties associated with the timescales of the project, for example the outcome of the planning application for the RCF could have a significant impact on the timing of the repository. However, given the substantial resources devoted to the Scientific Programme and the rapid progress being made in developing understanding of the Sellafield site, 1999 remains a sensible target for a decision on whether or not to apply to build a repository at Sellafield. Nevertheless, as supporting documentation for the RCF planning application makes clear, if after the first phase of the RCF programme the evaluation of the Sellafield site is not sufficiently confident to underpin a decision for or against, then more time would be taken to carry out further studies.

   The target timescale itself provides 4 or 5 years for data acquisition, interpretations and dialogue with the scientific community before even a Town and Country Planning Act application would be submitted in respect of a repository. There would then be a further 10 years before the safety regulators approved the Final Safety Case.
2. The Report suggests that consideration should be given to conducting R & D at Sellafield in two phases, the first relating to short-lived waste leading to the establishment of a safety case for those wastes and the

construction of a deep repository for them. A possible outcome would then be construction of a deep repository for short-lived wastes in a location which might subsequently prove unsuitable for long-lives wastes. In fact, it would make no economic sense to proceed at all at Sellafield unless there is good confidence that the site is adequate for disposal of long-lived wastes as well as short-lived ILW. (A separate facility for the latter would in fact be more economically provided in the shape of a surface or near-surface facility as at Forsmark in Sweden, Olkiluoto in Finland and Centre de l'Aube in France. Indeed the Royal Society itself, in its separate response to the Waste Management Review, has suggested that consideration should be given in the UK to a surface disposal facility for short-lived intermediate level wastes.)

The Report also suggests that, if adequate confidence in post-closure safety for longer lived wastes were to prove difficult to achieve for the potential repository zone as currently defined at Sellafield, then consideration should be given to the volcanic rocks further west. While Nirex would not at this stage finally rule out such a location, the current PRZ has been arrived at by a careful process of analysis and elimination. This process has included the examination of the technical feasibility of a repository located in the rocks suggested by the Study Group. These studies identified significant practical difficulties in the construction of such a repository and pointed to important construction and operational safety issues. These are linked to high rock pressures and ambient temperatures at the great depths involved. Such issues have to be given full weight alongside the geology and hydrogeology in selecting the zone for detailed investigations.

3. In the context of openness and peer review, the Report recognises the peer review of Nirex research (which includes site-specific as well as generic information) which is achieved through publication and international co-operation. The Report also recognises the willingness of Nirex to seek external inputs to development of its scientific strategy, as evidenced by initiation of the Royal Society Study itself and through the setting up of the Geological Review Panel. In line with other responsible organisations involved in research and development, the Company's approach is to publish information when it has been developed to a level of confidence appropriate for public review. In order to facilitate the Study Group's work, information was "fast-tracked" in the form of commercial-in-confidence preliminary reports subsequently being brought up to publication standard.

   Nirex has published many volumes of information on its research database and on site-specific information. Inevitably, confidence in risk calculations which depends on the performance of all elements of the system and their interactions, tends to follow behind the development of understanding of the performance of individual elements of the system. Nevertheless, Nirex has already published illustrative risk calculations for the Sellafield site in Report 525 and, early in 1995, preliminary results will be available from further safety assessment work, giving a view of Sellafield's post-closure safety performance together with the underpinning hydrogeological interpretation. Such interim calculations are, as the Study Group Report suggests, used in setting priorities for the ongoing Scientific Programme and in the refinement of repository design.

4. As previously indicated to the Study Group, the development of scenarios is an important element of Nirex's development of safety assessment methodology. The scenarios will address the consequences of climate changes, the importance of which is recognised in the Study Group's Report. The Company's strategy is that the development of such scenarios should be based on a sound understanding of current site conditions and should be informed by an adequate database developed from site characterisation activities.

5. The development of understanding of groundwater movements in fractured rock is a central element of Nirex's work to describe transport of radioactivity in the geosphere. The Company has made substantial progress both in modelling groundwater movements and in establishing a high quality database. This database includes substantial information on the geochemistry which is recognised as an important record of the history of the site and is important in constraining and validating models of present and future groundwater behaviour. It is recognised that more needs to be done in this area and that the Rock Characterisation Facility has a crucial role to play.

6. The Company notes the Study Group's conclusion that the RCF will provide a valuable base for site-specific studies. It is intended that scientific studies will be carried out in the RCF for a period of around

ten years, possibly longer. The first phase of the RCF, the sinking of the shafts, with a planned duration of nearly four years, will provide an important opportunity for validation of key models which underpin the safety assessment. This should lead to a significant increase in confidence in evaluation of the suitability of the site, as previously recognised in published advice provided by the consultants Intera to HMIP in 1990.

It may be that confidence is sufficient at the end of Phase 1 of the RCF to underpin a decision on a planning application for a repository. In that case, the later phases of the RCF would inform the final safety case which is required to seek permission to accept wastes into a repository. However, as clearly recognised in Nirex's planning application for the RCF, it could be that significant further work beyond Phase 1 in the RCF will be required before sufficient confidence is achieved to decide on the repository planning application. This approach to planning the RCF programme is in line with our overall approach to planning the Nirex programme as described earlier.

With respect to international participation in the RCF, Nirex intends to ensure that the best international experience is available to the RCF project and discussions have already been held with the European Union about their participation.

Back to NRX13 Menu Back to POE Menu Back to Homepage