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Radioactive Substances Act Authorisations for the Magnox Reactor Sites:

A Response from a Coalition of Anti-Nuclear Organisations

August 2000

Executive Summary

This report has been commissioned by a number of anti-nuclear groups in England and Wales in response to the Environment Agency's consultation of the draft authorisations of the Magnox power station and research sites. Our position is that these applications must be determined in accordance to the public interest, having regard to the most recent evidence on the safety of these plants, and the damage that may result from their radioactive and non-radioactive discharges.

In terms of the content of the applications, and the Agency's position on them, far more detail was required with regards to the justification for future decommissioning operations in order to demonstrate 'best practicable means'. There was also a general failure to consider the need to close the plants, either because of their clear inefficiency at generating nuclear energy, or because of the need to meet Britain's obligations under the OSPAR convention. The application for Hinkley Point A was, in our view, in need of total review because of the decision to close the plant – it is not possible to 'retrofit' the required standard of data at such a late stage in the process.

The Agency are required, under their statutory objectives, to implement actions that contribute to the attainment of sustainable development. In our view the consultation reports avoids the issue, failing to described in details how these applications will be determined in accordance with the tests and principles outlines in the UK Sustainable Development Strategy – in particular the application of the precautionary principle. Both in terms of the national guidelines on risk assessment guidelines, and the Agency's statutory guidelines, the Agency must evaluate any evidence that current practices may give rise to unforeseen or unintended harm. Then, having evaluated the evidence, they must justify either taking positive action to restrict potential harm, or be able to justify not taking positive action.

In terms of the Agency's general approach, they rely on the government's White Paper on Radioactive waste Management (Cm2919) to inform their decisions. In our view the Agency can no longer make valid decisions relying on the policies contained in Cm2919 as that document has been overtaken by events both in relation to radioactive discharges, and radioactive waste management.

There are a large number of modifications suggested to the draft authorisations dealing with site specific issues. We request that the Agency consider all these requests and give effect to them.

It is our view that the justification provided by BNFL, and amplified by the Agency in their consultation document, does not fully meet the objectives specified in the Basic Safety Standards Directive in terms of the justification of practice. Whilst the justification for decommissioning can be made within its own right (since there is no comparable operation in the non-nuclear sector), the justification for power generation fails to make comparisons with other options for power generation available in society. As well as testing the justification within the power generation sector, justification also needs to be made within the nuclear generation sector. This must be done to ensure efficiency, but no such comparisons are made.

As a general principle, the Environment Agency's approach to the consideration of risk must be more engaging of public opinion than the pessimistic approach of the HSE's Tolerability of Risk (TOR) reports. The Agency's views of public perception, based as they are on the TOR reports, are dated, and incompatible with recent decisions of the High Court. It is clear that the Agency must seek to re-evaluate the public acceptability of nuclear power since the assumptions that underpin the TOR reports are no longer valid. They must also make a clear statement on how the Agency, in recognition

of recent case law, will modify their procedures on the assessment of public concerns about nuclear power; and, as a result of this begin a process to identify the various different public concerns about the Magnox programme and seek to incorporate those concerns within the Agency's final determination of these applications.

In our view, the Environment Agency must direct BNFL to incorporate values for external costs and benefits. Whilst such values can be credited to the balance sheet for nuclear generation, we must also debit other costs. Unless BNFL's justification incorporates externalities it cannot satisfy the terms of the Basic Safety Standards Directive. Overall the economic assessments that forms the heart of BNFL’s justification case, and which relying heavily on discounted costs, are unrealistic because they do not factor-in the potential future regulatory risks. Also, as part of the economic case for the operation of the Magnox plants, the potential for economic difficulties at BNFL, because of the current problems relating to the loss of contracts after their recent safety breaches, must also be investigated before these applications are determined.

From an analysis of the data provided by the Agency and BNFL, it is clear that there is a large disparity in the operating efficiencies, in terms of power generation levels incurring certain levels of radioactive discharge, that must be considered when evaluating 'justification of practice'. In our view Sizewell A, Bradwell and Dungeness A should not be permitted to operate for power generation – the level of radioactive discharges cannot be justified by the quantities of energy production. Also, given the need to close Building B205 at Sellafield, the Agency should set a date for closing the Magnox stations within the next two or three years (2003 at the latest). In order that the complete closure of B205 can take place by 2020, as required by OSPAR, it must cease reprocessing by 2015 (five years early because of the time lag for discharge reductions). This is to allow 10 years for the reprocessing or other treatment of the substantial quantity of spent fuel that will arise due to the near simultaneous closure of all the Magnox stations.

For those sites that are in/entering the decommissioning phase, an effluent management plan is extremely important. Decommissioning, whilst leading to large decreases in atmospheric emission, can lead to increases in the discharge of some nuclides to sea. Therefore, BNFL should be required, to implement a system of developing new infrastructure, management and controls to ensure that the discharges from decommissioned sites achieve regular targeted reductions in the discharge of certain nuclides. Emphasis should be placed on those nuclides that have a tendency to bioaccumulate, all alpha-emitting nuclides, and nuclides that decay to alpha emitters within a few years of discharge.

In our view, spent nuclear fuel is a 'waste' material. As such, it requires authorisation for transfer away from the Magnox reactor sites to Sellafield. The Environment Agency must perform the necessary updating of the authorisations to include this material within the terms of the draft authorisations. We then we suggest that the new drafts are reissued for consultation as this would represent a substantial variation at each site. In terms of BNFL’s proposals to change to Magrox fuel at Wylfa and Oldbury, there are legal arguments for why the proposed change in fuel should be subject to an environmental statement. The Environment Agency must request an environmental impact statement detailing the potential changes to radioactive discharges as a result of the change in fuel. If this is not forthcoming then the Agency must not rely in any way on the introduction of Magrox fuel at a future date when determining these applications.

There are a number of issues relating to the longer-term decommissioning issues at the three closed sites, and also the other five sites at such time as BNFL decide to close them. We request that, for

the time being, the Agency refrain for giving permission for the 'free release' of materials produced from decommissioning operations until procedures and monitoring systems are introduced to ensure that the material that is released for recycling will have an extremely low probability of containing any material above free release limits. Given the disparity between releases from sites, we also request that the Agency give an account as to why the levels set for decommissioning at the various non-operation sites vary to such an extent. The Agency must explain how this can happen if BPM is being evenly at all sites, and what will be done to ensure that all sites, including reactors to be close in the future, meet similar low discharge levels.

There is a legal argument that the discharge of radioactivity from the Magnox sites will breach the Habitats directive, both in terms of the potentially lethal effects on protected species, and in the degradation of their habitats. There is a growing body of evidence that the damaging and lethal effects of radiation on wildlife can be demonstrated at levels far below those suggested as 'acceptable' by ICRP and others. The position of ICRP, that the protection of humans will ensure the protection of wildlife can be shown to be outdated – and is being criticised by other policy makers and commentators.

The acceptance that certain members of certain species will be killed as a result of the discharges from the Magnox plants results in a potential breach of the law. If the species concerned were protected, the discharges that resulted in that death would be unlawful if it could not be proven the discharges were unavoidable. The sub-lethal effects of discharges, that could lead to illness or loss of general/reproductive fitness, are also a relevant consideration in terms of Article 12(d) of the Habitats Directive and must be assessed by the Agency. It is up to the Agency and BNFL to prove that the discharges from the Magnox plants will not cause damage or death to protected species, or that if such effects do occur that these impacts could not reasonably be avoided.

The Agency needs to put far more work into modelling the impacts of the discharges, in particular the bioaccumulation of radionuclides, the long-term impacts of releases then factoring in radioactive decay, and the toxicological impacts. There are also potential errors in the modelling process that they must address. Finally, the Agency, in assessing doses from future discharges and in setting levels to control doses, must have regard to the impact of the historic legacy of radionuclides in the local environment. Where there is an excess of certain nuclides in the environment with the potential to increase radiation doses, then in future discharges of that radionuclide must be reduced.

The observed incidence of certain cancers surrounding nuclear establishments cannot be explained by current risk models. The failure of the radiological protection establishment in the UK and elsewhere to re-evaluate and justify their own models in the face of mounting evidence confirms the unreliability of these models. Our position is that there is sufficient evidence to question the basis of current dose–response models.

Studies of genetic variability demonstrate that the population cannot, in its entirety, be treated as homogeneous. The effects of homogeneity of risk models, and in the excess of illness that can be assumed to arise from radioactive discharges, must be considered within the Agency's risk estimates when determining these applications. Work on the Japanese bomb-survivor datasets demonstrates the shortcomings in the datasets on which the official risk models are based. The only other significant source of exposure data – radiation workers in the nuclear industry – also contains systematic errors due to dosimetry practices that may not give a representative set of data on the impacts of low-level radiation exposure. The use of this data to supplement the bomb-survivor

datasets is unlikely to provide a qualitative improvement to the risk estimates for populations exposed to low-level radiation. The implications of the research on the systematic errors in both bomb-survivor and nuclear industry worker datasets must be clarified in order that the Agency can validate it's own dose assessment procedures which are based on these datasets.

The basis on which doses are assessed as part of regulatory processes are open to question. New evidence suggests that both the biological mechanisms involved in cell irradiation, and the qualitative impacts of different types of radiation, are not properly quantified within the current dose equivalence methodology. The Environment Agency must demonstrate, given the recent evidence to the contrary, that current equivalent dose methodologies are suitable for use in order to evaluate health impacts.

The impacts of the Chernobyl accident have contributed valuable new data to the debate on radiation and health. The variability in the results of the post-Chernobyl studies can be explained by many factors – from the selection of geographical areas, to the size of populations and the quality of medical diagnosis. But the post-Chernobyl studies, when combined with other data on the risks of low level radiation, provide an argument that there exists a mechanism whereby ill health may be induced at lower dose rates than the current risks estimates project. The Agency should have regard to this recent evidence as it begins to quantify the level of error within the current dose risk estimates set by NRPB/ICRP.

Whilst NRPB may be the government body charged with advising on matters of radiological protection, the NRPB's advice cannot remove the obligations put upon the Agency under their statutory obligations to have regard to the best scientific evidence. There is no viable clean-up or remediation measure for radioactive contamination on the scale produced by the Magnox reactors and B205 at Sellafield. Therefore, in terms of the precautionary principle, the Agency do not require complete proof that current dose risk figures are incorrect before acting to achieve lower discharge levels. In terms of how big a cut the Agency should enact, that again should be a precautionary figure based upon the varying estimates of error within the current figures. In our view, the Agency should seek to cut emissions by a factor of 150 to 250 times.

If the Agency proceed in determining these applications without clarifying the validity of the risk factors on which the Agency's judgement is based then those opposed to the granting of these applications may seek a review of the Agency's decision.

In conclusion, we welcome the opportunity to comment on these draft authorisations. However, in our view, there is still a large body of work remaining to be completed in terms of the legal, procedural and technical issues. Some are minor modifications. Many go right to the heart of the justification of the operation of these sites, and require that the Agency consider particular legal blocks that may prevent the determination of the authorisations. We request that, as part of the decision documents, the Agency gives a clear explanation of all these issues, together with the reasons why the Agency could/could not accept our objections.

Contents

Appendices

This report has been produced in two volume – the main report, and three appendices containing copies of information referenced in the main report. The main report is self-contained, including all evidence and information relating to the arguments advanced in response to the Magnox consultation reports. The appendices are produced for information purposes only, and are intended to simply the process of investigating the objections raised in this report. The appendices are arranged as follows:

Annex 1: Radiation, health and the environment documents

Annex 2: Legal and procedural documents

Annex 3: Engineering and economics Documents

Abbreviations

AGR	Advanced Gas-cooled Reactor – the generation of reactors that came after Magnox.
BPM	'Best Practicable Means' a demonstration that the best technological methods to reduce pollution have been used by the site operators.
BNFL	British Nuclear Fuels Ltd – the operator the Magnox stations.
^{14}C	Carbon-14, a radioactive element produced in reactors.
^{137}Cs	Caesium-137, a radioactive element produced in reactors.
^{60}Co	Cobalt-60, a radioactive element produced in reactors.
Cm	A 'command paper' of Parliament – a statement of the intended policy of government in relation to an issues, called a 'white paper' (note, previously to *Cm*, they were abbreviated as *Cmnd*).
Cm2919	The 1995 White Paper on *Radioactive Waste Management*.
DETR	The Department of the Environment, Transport and the Regions.
DoE	The Department of the Environment (forerunner, pre 1997, to DETR).
EPA	The Environmental Protection Act 1990.
GBq	Giga-Becquerel – one thousand million Becquerels, a Becquerel being the unit of activity, equivalent to one nuclear disintegration per second.
GDP	Gross Domestic Product – a valuation of the counties economic production
Gy	Gray – the unit of absorbed radiation dose
HSE	The Health and Safety Executive – the government agency that regulates the safety of workplaces and nuclear facilities
^{129}I	Iodine-129, a radioactive element produced in reactors.
ICRP	The International Commission on Radiological Protection – the body that recommends radiation risk/radiation protection standards at the international level.
LET	'Linear Energy Transfer' – a model for how radioactivity transfers energy to cells.
MRC	The Medical Research Council – a government-funded research body conducting research into radiation and health.
MWe	One megawatt of electrical generation
NII	The Nuclear Installations Inspectorate – the division of the HSE that regulates the safety of nuclear establishments.
NRPB	The National Radiological Protection Board – the government's advisors on radioactivity.
OSPAR	The Oslo and Paris Commission – the body setting standards for polluting discharges into the environment at the European level
PWR	Pressurised Water Reactor – the generation of reactors that followed AGR's
RCEP	Royal Commission on Environmental Pollution.
RSA	Radioactive Substances Act 1993 – the main legislation controlling the holding, transfer and discharge of radioactive substances
^{90}Sr	Strontium-90, a radioactive element produced in reactors.
^{99}Tc	Technetium-99, a radioactive element produced in reactors.
TBq	Tera-Becquerel, one million, million Becquerels
TOR	HSE's 'Tolerability of Risk' reports
α particle	'alpha' particle – an particle consisting of protons and neutrons ejected from the nucleus of a decaying atom.
β particle	'beta' particle – and electron ejected from a decaying atom.
γ ray	'gamma' ray – a high-energy electromagnetic wave created as energy is released from an atom undergoing radioactive decay.

1. Introduction

This report has been written by Paul Mobbs, and commissioned on behalf of a number of grass-roots organisations in response to the public consultation by the Environment Agency on the Magnox radioactive discharge authorisations.

The specification for this report was to review the documentation produced by the Environment Agency to check compliance with current national and European policy objectives. Also, to study the case made for the production and discharge of radioactive materials, possibly with a view to informing future legal action should the Agency not have regard to the arguments advanced in the report.

The need for the report was identified at the 15th International Standing Conference on Low Level Radiation and Health that took place in Reading during July. A number of groups there agreed to work together to raise funds for a detailed technical appraisal of the consultation documents. To this end a number of groups have donated money for the production of this report, including:

- Blewbury Environmental Research Group;
- Colchester CND;
- The Free Range Network;
- Friends of the Earth Cymru Local Groups Network;
- The Green House/Dinefwr Green Group;
- CND Cymru;
- Nuclear Free Local Authorities Association;
- The Welsh Anti-Nuclear Alliance.

The report reviews various different issues raised by BNFL's applications to discharge radioactivity and transfer radioactive wastes from the Magnox sites. These issues are grouped under four main headings:

- **Legal and procedural issues:** This section examines the general framework within which the Agency must consider these applications. In particular, the responsibilities of the Agency to concerned members of the general public. It also examines the current state of government policy relating to nuclear power and radioactive waste.
- **Engineering and Economics:** This section considers the operation of the plants, and the aspects of justifying their operations. It also considers the management of waste and decommissioning.
- **Environmental Impacts:** This section considers the mechanisms for the discharge of radioactivity to the environment, and the impacts of discharges on the environment – in particular wildlife.
- **Human Health Impacts:** This section examines the evidence relating to the human health impacts of the Magnox discharges – in particular, the validity of the risk factors used by the Agency. The basis of the Agency's risk assessment is examined, and a case made that the Agency must adopt a precautionary approach.

- **Site Specific Issues:** This section deals with the detail of the draft authorisation for each of the Magnox sites, and where relevant makes reference to other issues outlined in the preceding four sections.

The main points of these four sections are then drawn together in the 'Conclusions and Recommendations' section. Note also that this report has been written for the benefit of those groups commissioning the study as well as for the purposes of the Environment Agency's consultation. It therefore contains a level of detail and referencing that may not ordinarily be expected by the Agency.

Throughout the report a number of references and sources are noted. Those that may not be readily accessible are reproduced, in part or in full, in the appendices of the report. Some reports are referenced through the Internet.

To aid the deliberations of the Environment Agency, as well as providing a paper copy of the report, there is also an electronic copy supplied on a CD ROM. The CD ROM is compatible with PC's running Windows 95 (with service pack 2) or better. Copies of the report are provided in Word 97 and Adobe Acrobat 3 file formats.

Finally, if the Agency have any queries regarding the content of the report, please do not hesitate to get in touch. Also, if representatives of the Agency wish to meet in order to discuss details in the report further, we would be happy to arrange this.

Acknowledgements

I would like to thank all those who have contributed and assisted in the development of this report.

Please note that this report has been developed by myself as a ‘professional’ response to the Environment Agency’s consultation. It has been commissioned by a number of interested groups to provide a different perspective on the consultation process. This report does not hold or bind any group or member of the groups who have funded this report to agreeing with or supporting the conclusions drawn. All the objections submitted by those groups and individuals who have supported the development of this report stand as separate responses to this collective response.

Paul Mobbs
August 2000

2. Legal and Procedural Issues

This section deals with the legal and procedural issues relating to the Magnox applications. In particular, the interpretation of the procedural framework governing the authorisation of radioactive discharges, waste transfers, and the protection of the public. Documents relevant to the consideration of the arguments in this section are provided in Annex 2.

2.1. The application and consultation documents

Section 16 of the RSA enables the application for authorisation of the accumulation or the disposal or radioactive materials. The form of the application is not specified, other than the requirement that the appropriate fee be included with the paperwork. When evaluating the paperwork provided by BNFL the question that must be asked is, '*is the detail supplied with this application sufficient for the Agency to determine it within their legal responsibilities?*' As is detailed in the rest of this report, our opinion is that there is uncertainty regarding a wide range of legal and technical matters.

In general, the documentation produced by BNFL relies upon many assumptions regarding the authorisation of radioactive discharges and the management of radioactive waste. Principally:

- That government policy supports the activities BNFL are seeking to authorise;
- The activities can be carried out within acceptable margins of risk; and
- The activities that are the subject of the applications are essential to the economy.

It is our position that none of these arguments are completely true. Government policy may 'support' the operation of nuclear power stations. But this support must operate within the framework of both national and European laws. Likewise, accepted notions of risk can be challenged as new information emerges about the effects of past practices. The role of the Agency, in terms of it's responsibilities to advance sustainable development[1], should be to provide a challenging role to the applicant in the public interest. That does not appear to be the position of the Agency in this case.

The Agency's consultation documents, whilst comprehensive, are difficult to assimilate. There is a considerable amount of justification between the documentation for each site. For those who are not experienced in reviewing technical documents, tackling around 800 pages per site is not simple.

In terms of providing the public with useful information to inform their response, it would have been more worthwhile to combine the duplicated documentation on each site within one volume. Then, rather than obfuscating the information within a large volume, highlighting the differences *between* the applications in order that the public could have a clear view of the main issues.

Regarding the Environment Agency's web site and the CD ROM, it was very useful having information in this form. However, the use of Adobe Acrobat 4 as the standard is a disadvantage to many members of the public. Acrobat 3 still tends to be the standard. And whilst the software may be downloaded free from the Internet, for those with older equipment download 6 megabytes of data

[1] Section 4, The Environment Act 1995.

would take a long period, it may be costly, and such long downloads are prone to errors requiring more attempts to download. In any case, older computers find it difficult to run Acrobat 4 with reasonable efficiency because of the size and complexity of the program.

Finally, we welcome the three month consultation period. The ability to submit response by email as well as fax and post is also welcome. We hope similar response periods, of a minimum three months, are used in the future.

In conclusion, we see the main points in relation to this consultation are:

- **The opportunity to comment on the applications for the Magnox sites is welcomed.**
- **While we welcome the efforts to provide comprehensive documentation, the format of the reports, and the large amount of duplication between sites, raise issues about the 'readability' and 'comprehensibility' of the consultation documents for the general public.**
- **Likewise, the use of the latest software will always cause problems for the general public.**
- **We hope that the Agency can work on resolving these difficulties in the future.**

2.2. Sustainable development and the legal obligations on the Environment Agency

Section 4 of The Environment Act 1995 requires the Environment Agency to assist in the attainment of sustainable development. To assist this objective, in November 1996 the 'statutory obligations' of the Agency on sustainable development were defined in a government statement – *The Environment Agency and Sustainable Development*[2]. At that time the UK Sustainable Development Strategy provided only a general definition of sustainability. Also, in terms of radioactive substances, the Agency's sustainability guidelines simply defined government policy in terms of the 1995 White Paper on *Radioactive Waste Management*[3]. Today, the basis of guidance on sustainable development has changed:

- The UK Sustainable Development Strategy has been updated. The new policy document – *A Better Quality of Life*[4] – provides a far more detailed analysis of what sustainability consists of. It also imposes new 'decision-making' tests5 that affect the Agency's policy reviews and regulatory decisions.
- The national policy on radioactive waste management has been under review for a long period of time following the refusal to permit test facilities associated with Nirex's deep

[2] *The Environment Agency and Sustainable Development*, Department of the Environment November 1996 (ref. 96EP189/1). Relevant sections of these guidelines have been reproduced in Annex A2.4, page A2-27.

[3] *Review of Radioactive Waste Management Policy – Final Conclusions*, Cm2919, July 1995.

[4] *A Better Quality of Life – A Sustainable Development Strategy for the UK*, Cm4345, May 1999.

[5] The 'ten approaches to decision making' are detailed in Chapter 4 of the Strategy. This chapter has been reproduced in Annex A2.6 of this report, page A2-43.

repository. Given that the strategy of Cm2919 relied upon the Nirex repository being given the go-ahead, it is questionable whether it's policy guidelines can be relied upon. Government policy has also been undergoing significant review since the critical report of the House of Lords Science and Technology Committee[6]. It is possible that a new policy statement to replace Cm2919 will be issued before the authorisations are issued.

- In terms of radioactive discharges, there is a new policy dimension in relation to the OSPAR convention [see section 3.3] that is not considered in Cm2919. Currently DETR are consulting on the strategy for meeting the OSPAR discharge reductions, and this process may not be concluded before these applications are determined. DETR are also proposing to issue a consultation[7] in relation to revising the statutory guidelines under section 4 of The Environment Act specifically on regulating radioactive discharges from nuclear licensed sites. Given that the whole basis of issuing and regulating discharge authorisations is about to undergo fundamental change, applying the principles of Cm2919 appears unwise.

Therefore, in terms of applying the principles of sustainable development in accordance with the Agency's statutory obligations, stating that conforming with Cm2919 is 'sustainable' is no longer a valid position. Cm2919 has been overtaken by events, both in terms of the management of radioactive waste, and the regulation of radioactive discharges. The Agency faces a decision between two options:

- Refuse to determine these applications – perhaps more than 12 months – until the new policy guidelines are agreed (this could actually be the worst option because of the need to cut site emissions immediately under OSPAR); or
- Determine these applications now by interpreting the likely new structure of the regulatory regimes within the discretion the Agency has over setting the terms of authorisations.

The demise of Cm2919 as a valid policy document is only one aspect of the problem the Agency face. They must also consider the new decision-making tests set in the new UK Sustainable Development Strategy. These are:

- Putting people at the centre;
- Taking a long-term perspective;
- Taking account of costs and benefits;
- Creating an open and supportive economic system;
- Combating poverty and social exclusion;
- Respecting environmental limits;
- The precautionary principle;
- Using scientific knowledge;
- Transparency, information, participation, and access to justice;
- Making the polluter pay.

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[6] Third Report of the House of Lords Science and Technology Committee, *The Management of Nuclear Waste*, HL41 Session 1998-9, March 1999.

[7] Announced in Chapter 1, paragraph 1.5, of *UK Strategy for Radioactive Discharges 2001-2020 – Consultation Document.*

It is clear that these tests, particularly in relation to a people-centred approach, respecting environmental limits, and using scientific knowledge/the precautionary principle, have not been objectively evaluated through the consultation reports produced by the Agency. In particular, the issues regarding the basis of environmental limits, which are being challenged by new scientific knowledge, has been completely ignored.

Sustainable development, as a decision-making philosophy, requires that regard is had to environmental, social or economic capacity limits. It is therefore crucial to provide assessments of the available environmental capacity before an authorisation is granted. An example would be the level of radioactive discharges that will not lead to bioaccumulation and/or damage to species within the environment. From the contents of the consultation reports, no such work has been undertaken in relation to applications – all discharges are assessed in terms of 'numerical limits', not based upon a local environmental assessment. These numerical limits assume that the 'dilute and disperse' approach will minimise the impact upon the environment and human health. There is emerging scientific evidence that this is not the case [see sections 4.1 and 5 below].

The second key thread in sustainability-based decision-making is the precautionary approach. Where there is uncertainty about impacts, then full scientific proof shall not be required before action is taken to address the concerns regarding environmental damage. The Agency's statutory guidelines draw attention[8] to various different sources of guidance on how to handle issues relating to sustainable development and environmental impacts. One of these sources that has particular relevance in relation to these applications is the DoE's risk assessment guidelines[9]. These guidelines have recently been updated[10], with the co-operation of the Environment Agency. These two sets of guidelines together[11] provide guidance to the Agency on applying the precautionary principle.

Uncertainty with regard to environmental protection must be addressed by the Agency. This is primarily with regard to:

- *Regulatory uncertainties* – determining whether current standards will be acceptable given the significant changes to the regulatory regime described earlier;
- *Environmental impacts* – particularly with regard to the effects of radioactive discharges on wildlife; and
- *Human health impacts* – determining whether the current radiation risk factors set by ICRP are valid given recent scientific evidence on radiation risk.

The latter of these poses a serious question with regard to the Agency applying the precautionary principle. The potential effects of radiation induced 'genomic instability' [see section 5.5] are not limited to the individual contaminated with radioactivity. The effects potentially extend for generations into the future[12]. When considering the application of the precautionary principle it is necessary to weigh the potential effects of the harm caused against the impacts of restricting or preventing certain

[8] For example, section 5.2.3, *The Environment Agency and Sustainable Development*

[9] *A Guide to Risk Assessment and Risk Management for Environmental Protection*, Department of the Environment, June 1995.

[10] *Guidelines for Environmental Risk Assessment and Management*, DETR July 2000.

[11] Relevant extracts from these documents are provided in Annexes A2.7, page A2-45, and A2.8, page A2-50.

[12] See a review of the work of Eric Wright of the MRC in relation to genomic instability in the *New Scientist*, 11/10/97. This article, *Radiation Roulette*, is included in Annex A1.2, page A1-97.

types of economic activity. How does the Environment Agency value the pollution of the human gene pool? Unless the Agency seeks to address these issues then it cannot discharge its responsibilities to act sustainably.

Finally, in terms of sustainable development's requirement for a 'holistic' assessment of the issues, we have to question the approach of the Agency in evaluating these applications. The whole of the Magnox fuel cycle should be evaluated. This is particularly important with regard to the 'back end' of the operation of Magnox reactors – the reprocessing of spent fuel at Sellafield [see section 3.9 below]. Magnox fuel is unique. Building B205 at Sellafield is the only plant equipped to reprocess this fuel. But building B205 also produces around 80% of the radioactive discharges to the Irish Sea, and under the terms of the OSPAR agreements it must be closed as soon as possible.

Also, in terms of the holistic assessment, and the new risk assessment guidelines, we must also look at alternative options for securing the perceived benefits produced by the damaging activity. This is particularly relevant in this case. There are many other options available for producing energy other than nuclear power. Renewable energy options also meet the imperatives on developing energy capacity that does not increase global carbon dioxide levels. When assessing the costs and benefits of these applications, given the accepted problems that nuclear generation has, the options for alternatives to the power generated by these plants must be considered.

If the Agency is to take a truly holistic view, it must also have regard to the implications of permitting, or not, the operational discharges from the Magnox reactors. Such consideration must also include the reprocessing of spent fuel. Due to its design, and the materials used in its construction, Magnox fuel must undergo some form of treatment to make it safe for long-term storage. Reprocessing is one of those options, but there are others, such as separating the fuel casings and then processing the spent uranium into a more stable form for long-term storage. It is arguable that the Environment Agency does have legal authority over the treatment of spent fuel [see section 3.6 below]. Therefore the issue of whether the operation of these plants, and the reprocessing of that spent fuel in B205 at Sellafield, is a valid consideration for the Agency when determining these applications.

In conclusion, the Agency, in terms of the case presented in the consultation documents, have not properly outlined or discharged their legal obligations in relation to the 'attainment of the objective of sustainable development'. In particular:

- **In the consultation reports the Agency effectively ducks the issue of taking the decisions on these applications in accordance with the tests and principles outlines in the UK Sustainable Development Strategy, and the Agency's own statutory guidelines.**
- **The Agency can no longer make valid decisions relying on the outmoded policies contained in Cm2919. That document has been overtaken by events both in relation to radioactive discharges, and radioactive waste management.**
- **In terms of both the 1995 and the recent risk assessment guidelines, and the Agency's statutory guidelines, the Agency must evaluate any evidence that current practices may give rise to unforeseen or unintended harm. Then, having evaluated the evidence, they must justify either taking positive action to restrict potential harm, or be able to justify not taking positive action.**
- **At no point in the consultation documents have the Agency, or BNFL, discussed the**

large uncertainties that exist in relation to the environmental impacts of radioactive discharges. Likewise, there has been no objective quantification of the capacity of the environment to accept discharges without unacceptable levels of harm.

- **In terms of regulating radioactive wastes, there are few other such issues where the Agency must be obliged to consider, in relation to all aspects of these applications, to apply the precautionary principle. But the Agency's reliance on numerical limits, and on outdated or untested assumptions within dated government policy documents, they have precluded the kinds of assessment that are necessary to test if precautionary action is required.**
- **All-in-all, given the various issues raised in relation to the attainment of sustainable development, it is our view that the Agency have not properly interpreted or discharged their legal and policy obligations in relation to sustainable development.**

2.3. The justification of the activities seeking authorisation

The ICRP's publications form the basis for radiological protection. These state[13]:

> *No practice involving exposures to radiation should be adopted unless it produces sufficient benefit to the exposed individuals or to society to offset the radiation detriment it causes.*

This principle forms the basis of 'justification of practice'. This principle is incorporated in the Euratom Basic Safety Standards Directive[14]. The application of this principle was further clarified in the High Court as part of Greenpeace's review of the go-head for the THORP plant[15].

The bounds for the justification of practice are not limited merely to the direct operation of the plant. As the wording implies, it must include the context of the plant within society. Many of the arguments in relation to this were examined as part of the government's White Paper on the *Prospects for Nuclear Power in the UK*[16]. But given the change in national policy objectives over the last five years, and the uncertainties about long-term waste management options, the conclusions presented in this white paper need to be considered within the context of current emerging policy. There are also two other significant factors that must be considered. Firstly, the white paper did not examine the arguments for sustainability in relation to nuclear power. Secondly, and peculiar to the Magnox plants, they do not have a future. They are all within a very few years of having to close.

Section 6B of the Agency's consultation report examines the justification for operating the Magnox stations. This in turn is a digest of the documentation supplied by BNFL. The justification is limited purely to the issue of the plants operation. This raises two points:

- For those sites that are currently decommissioning, the arguments must relate to the

[13] Paragraph 112(a), *Publication 60*, ICRP 1991. See also *ICRP Publication 26*, ICRP 1977.

[14] Euratom Directive 96/29, May 1996.

[15] *R v Secretary of State for the Environment and others, ex parte Greenpeace Ltd and another*, All England Law Reports 4 [1994], 382-384. The report of this case is reproduced in Annex A2.3, page A2-10.

[16] *The Prospects for Nuclear Power in the UK*, Cm2860, May 1995.

operation of those sites in a manner that secures the long-term safety of the radiological inventory present with the least detriment to the environment and society. This has been done in a minimal way.

- For those sites that are generating power, the arguments advanced relate to the operation of the sites as nuclear reactors, not as power stations. The justification for operating those plants as power stations cannot solely rest on their unique characteristics as nuclear reactors. The justification must reflect their intended function – the generation of electricity.

In terms of the stations generating power, the documents supplied by BNFL, and the Agency's interpretation of them, has completely failed to justify their operation for the generation of power. Any justification for a nuclear power station, in terms of its context within the wider industrialised society, must consider:

- *The need for the energy* – if there is no pressing need for the power then the practice cannot be justified, which is essentially an economic argument [see sections 3.1 and 3.5 below];
- *The efficiency of generation* – this can be looked at in various ways, but logically it must be a comparison, with other nuclear generating plants, of generation vs. radiological impact indicators [see section 3.2 below];
- *The positive environmental benefits that may balance environmental disbenefits* – in terms of nuclear generation that is usually the offset for fossil-fuel based energy generation, but this is not unique given other technologies also can generate energy without creating carbon dioxide;
- *In terms of an overall societal case, the sustainability of the proposal must also be examine* – as a general guide this must satisfy the requirements of the relevant national policy guidelines on sustainable development [see section 3.9 below].
- *As an overall holistic appraisal, and having regard to risk assessment criteria, what are the possible options for these sites, and what are the relative impacts of each* – this must include both the consequences of operation, the consequences of decommissioning, and the externalities that arise from these options.

It is not enough to justify the operation of a nuclear generating plant in its own right. The justification of practice must be based on an evaluation of the 'objective' of the practice, not just the operation of a nuclear facility in its own right. Section 3 of this report considers these issues in detail.

In conclusion:

- **It is our view that the justification provided by BNFL, and amplified by the Agency in their consultation document, does not fully meet the objectives specified in the Basic Safety Standards Directive, and which were tested in the High Court as part of the Greenpeace case.**
- **Whilst the justification for decommissioning can be made within its own right, since there is no comparable operation in the non-nuclear sector, the justification for power generation fails to make comparisons with other options for power generation available in society.**

- **As well as testing the justification within the power generation sector, justification also needs to be made within the nuclear generation sector. This must be done to ensure efficiency, but no such comparisons are made.**

The detail for each of these objections is supplied in section 3 of this report.

In our view, on the basis of the failure to justify the operation of the generating plants within the context of the whole energy generation sector the Agency cannot determine these applications. In terms of 'justification of practice' they are incomplete.

2.4. Public perceptions of hazard and risk

Part 2 of the various Environment Agency consultation reports introduced the 'concept of risk'. It is our view this explanation of 'risk' is out of date. The concepts explained by the Agency derive from the Health and Safety Executive's (HSE's) report, The Tolerability of Risk from Nuclear Power Stations (TOR)[17]. Today the use of this report can be considered flawed because:

- The framework for the document was defined within the observations of Sir Frank Layfield in his report on the Sizewell B inquiry. However, since that date, there has been and immense change in the assumptions of the benefits of nuclear power. Also, the systems – such as the deep disposal of radioactive waste – on which the continued operation of nuclear facilities were predicated have since run into problems. In particular, the recent review of the nuclear industry[18], reviews of the energy sector since then, and the development of the policy of sustainable development, have invalidated the basis of the TOR report.
- The process by which the HSE compiled the report was not a valid consultation given its limited nature, poor publicity, and the narrow restrictions placed upon the interpretation of responses[19].

The 'science' of risk perception and communication, as well as the law on how the public's view on risk should be interpreted, have developed greatly since 1988. Recent reports framed in relation to the 'public understanding of science' place risk perception in a very different light to the TOR report.

The development of 'risk perception' in relation to nuclear facilities has, over the past 25 years, been a rather biased process. As with many science-based activities that are of public concern, the view established by regulators and other agencies has been that the activities are acceptable 'if only the public could understand the issues involved'. It is important to understand that, in terms of law, and in terms of a democratic civil society, the view of the public, even if scientists or technologists disagree with it, is a valid and relevant issues that must be taken into account by decision makers.

The development of risk concepts in the manner of the TOR reports can be seen as a long process of

[17] *The Tolerability of Risk from Nuclear Power Stations*, Health and Safety Executive, February 1988.

[18] *The Prospects for Nuclear Power in the UK: Conclusions of the Government's Nuclear Review*, Cm2860, May 1995.

[19] There are some details on this in the follow-up report, *Comments Received on The Tolerability of Risk from Nuclear Power Stations*, Health and Safety Commission (HSC) 1988.

'top-down' evaluations of the acceptability of hazardous practices. The first report to look at the acceptability of nuclear power in details – the Flowers Report[20] in 1976 – gave only a passing consideration to public perception of risk. The approach of the Commons Environment Committee's report on radioactive waste[21] from the mid-80s is also broadly similar to the basis of the TOR reports – which is essentially that the public don't understand, and are therefore not able to make valid judgements of risk. This trend of interpreting the public's mistrust of nuclear power as irrational has continued into the 90s, most recently in the House of Lords report on radioactive waste management[22]. Certainly, the Government's response the Lord's report[23], with its emphasis on streamlining public inquiries to speed the development of radioactive waste facilities[24], is bound to have an effect counter to that intended and poison the public's perception of nuclear power even more. But things are beginning to change. For example, a more objective report on public views on radioactive waste is to be found in the recent POST report on radioactive waste[25]. This assesses the acceptability of hazards and risks within the more recent framework of 'bottom-up' evaluations of the public's views.

Perhaps the most significant evaluations of public perception of risk have emerged through the debate over the genetic modification of foods. The recent House of Commons report on genetically modified foods[26] paints much the same view on public perceptions of risk as previous Parliamentary reports on radioactive waste. However, the early research into the issues of genetic modification found some well-founded concerns behind the supposed 'ill-informed' reaction to the genetic modification of food[27]. Recent reports have also found that the approach of the public is well-informed about the important issues in relation to concerns about scientific development, and that the public are able to adequately balance risks and benefits associated with technological development[28].

The position of the Agency, as expressed in the consultation reports, continues the trend of 'top-down' evaluations of risk that has not changed markedly since 1988. This is not acceptable. It is clear by the approach the Environment Agency has taken to this consultation that they believe there is public concern regarding discharges from the nuclear sites. No statutory process exists under the RSA for general public consultation, but the Agency has recognised that public consultation need to

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[20] Paras. 521-524, Royal Commission on Environmental Pollution's Sixth Report, *Nuclear Power and the Environment* (the Flowers Report), Cmnd. 6618, September 1976.

[21] Chapter 12, First Report of the Commons Environment Committee, *Radioactive Waste*, Session 1985-6. HC191-I.

[22] Chapter 5, Third Report of the Lords Science and Technology Committee, *The Management of Nuclear Waste*, Session 1998-99. HL41. March 1999.

[23] *The Government's Response to the House of Lords Select Committee on Science and Technology Report on the Management of Nuclear Waste*, DETR October 1999.

[24] In reference to the consultation paper, *Modernising Planning – Streamlining the processing of major infrastructure projects and other projects of national significance*, DETR May 1999. Ref. 99PP0152.

[25] *Radioactive Waste – Where Next?*, Parliamentary Office of Science and Technology report No.106, November 1997.

[26] Paragraphs 21-25, First Report of the Commons Science and Technology Committee, *Scientific Advisory System: Genetically Modified Foods*, Session 1998-99. HC286-I. May 1999.

[27] *Uncertain World – Genetically Modified Organisms, Food and Public Attitudes in Britain*, Grove-White et. al., Lancaster University 1997

[28] *The Politics of GM Food: Risk, Science and Public Trust*, Economics and Social Science Research Council *Global Environmental Change Programme* Special Briefing No.5, October 1999.

be part of the process of authorisation for this site. Therefore, it is important that the Agency re-evaluate their approach to the consideration of public risk. Not least, because the more 'bottom-up' views of the acceptability of risk and hazard may now be legally enforceable. There is a growing body of law on the consideration of public perceptions of risk to human health and the environment.

Case law on public perception has developed markedly in non-nuclear sectors over the past decade. It began with the Gateshead[29] case where the validity of public perception in the face of unknown hazards was tested in detail. The law developed further with the Bolton Incinerator cases, bringing the assessment of the 'Best Practicable Environmental Option' (BPEO) into case law. The Browning Ferris case[30] takes the 1990 Glidewell judgement further. The Court of Appeal allowed the application by Newport Borough Council and quashed the decision by the Secretary of State. This is described at the time as[31]:

> *...a very significant decision, for it establishes that -*
>
> *(i) public concern, even if objectively unfounded, is a material consideration to be taken into account...*
>
> *(ii) Arguably this conclusion has wider application. There appears to be no reason why public concern per se requires objective expert justification.*
>
> *In some circumstances an objectively unfounded, albeit genuine, fear (i.e. public concern) can of itself constitute a valid reason for refusing planning permission.*

We consider this to be important and, together with the West Midlands and Broadlands cases[32], gives powerful evidence that the local concerns can weigh heavily in the authorisation of development or of polluting discharges. This issue was examined at length recently in relation to significant non-nuclear developments, and it was concluded[33]:

> *Recent cases, confirming that public concern is a material consideration, pave the way for potentially the most significant development in planning law since the introduction of section 54(A) of the Town and Country Planning Act 1990... recognition that "NIMBY" objections do posses real teeth!*

Recent cases have shown that the concern over health effects, and the public's perception, is growing as a new tenet of environmental law. Earlier this year the report on a planning appeal[34] by UK Waste into a waste site near Skelmersdale, Lancashire, was refused partly on the basis of the concern over apparent, although not expressly demonstrated, links between landfill emissions and health. This decision was later subject to a judicial review. All the issues relating to landfill, health effects and public perception were upheld. This is a significant development since, rather like the

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[29] *Gateshead Metropolitan Borough Council v. Secretary of State for the Environment and Northumbrian Water* [1993] 67 & CR179; [1994] affd., 71 P & CR350

[30] *Newport Borough Council v SoS Wales and Browning Ferris Environmental Services Ltd* [1998] JPL 377

[31] *Public Concern – The Decision Maker's Dilemma*, Neil Stanley, JPL [1998] 919-934

[32] *West Midlands Probation Committee v. Secretary of State for the Environment and Walsall Metropolitan Borough Council* [1998] JPL. 388. *R. v. Broadland District Council and others ex parte Dave, Harpley and Wright*, January 1998.

[33] *Public Concern – The Decision Maker's Dilemma*, Neil Stanley. JPL [1998] 919-934

[34] Appeal by UK Waste Management Ltd, Round 'O' Quarry, Cobbs Brow Lane, Skelmersdale, Lancashire. Planning Inspectorate appeal ref. APP/Q2371/A/97/288746

relationship between environmental radiation and health effects, the relationship between landfill and health effects has yet to be accepted as a matter of government policy. In our view, the same principle applies in the case of the radioactive waste authorisation for the Magnox sites. There are varying levels of concern with regard to the operation of the reactors and their decommissioning. This has increased recently following the revelations about management and safety practices at BNFL.

In conclusion, the Environment Agency's approach to the consideration of risk must be more engaging of public opinion than the pessimistic approach of the TOR report. Such views of public perception are dated, and incompatible with recent decisions of the High Court. It is clear that the Agency must:

- **Seek to re-evaluate the public acceptability of nuclear power since the assumptions that underpin the TOR reports are no longer valid;**
- **Make a clear statement on how the Agency, in recognition of recent case law, will modify their procedures on the assessment of public concerns about nuclear power; and, as a result of this**
- **Begin a process to identify the various different public concerns about the Magnox programme and seek to incorporate those concerns within the Agency's final determination of these applications.**

Case laws on public perception, even if the Government still do not wish to accept the principle in statutes, give the public the right to have their 'fears' on nuclear power diligently investigated by the Environment Agency. The Environment Agency are required to determine an authorisation for pollution that has uncertain and poorly characterised effects. There is genuine public concern about adverse health effects from radioactive discharges, backed up by significant evidence to validate those concerns. The Environment Agency must therefore give strong weight to the opinions expressed by the public in terms of health effects, and act to restrict the terms of, or even refuse, the applications in order to address the substance of these objections.

2.5. The implications of the Human Rights Act

This may be the first major decision the Agency will have to take where the Human Rights Act 1998 will be in effect[35]. This has significant implications for how the Agency deal with objections to the authorisations, but more significantly how they seek to evaluate the public's concern about hazards to health, damage to property and the risks to life.

In constitutional terms, the *Human Rights Act 1998* is of fundamental importance. It is the first major legislation affecting human rights for over 300 years. Yet it is not exactly a major constitutional restructuring – its uses are limited. All it does, as the Government's White Paper[36] concedes, is to enact into UK law the rights contained in the 1950 *European Convention on Human Rights* (for which

[35] The Act commences on the 2nd October, 2000.

[36] *Rights Brought Home*, Cm3782, October 1998

the United Kingdom led the drafting, and was the first signatory). It allows disputes to be dealt with in the courts of this country, rather than requiring victims to takes their cases to Strasbourg at great expense and delay.

But this has significant impacts on how the Agency does its business. There are four Articles in the Convention that could directly impact the role of the Agency in determining these applications:

- Article 2 creates a right to life under the protection of the law. The 'right of life', particularly in terms of the duty of the Agency under section 6(1) of the Act to act in accordance with the Articles, has particular relevance here. The discharge of radioactive materials, with the associated statistical risk of death to certain sections of the public, does represent a threat to life. The decision as to whether the Agency have acted in conflict to Article 2 will therefore be whether or not the risks to the public are 'acceptable'.

- There is a right to 'fair process' under Article 6. This creates the right to a fair trial -

  "in the determination of his civil rights and obligations or of any criminal charge against him, everyone is entitled to a fair and public hearing within a reasonable time by an independent and impartial tribunal established by law...."

  In practice, the principle of a 'fair trial' also extends to the determination of the applications submitted by BNFL. Therefore, if the Agency were to Act in a way prejudicial to those members of the public who had raised objections, then they could be in breach of Article 6.

- Article 8 establishes a right to respect for private and family life. This prohibits interference by a public authority except where it is lawful and necessary in the interests of such matters as public safety, national economic well-being and protection of health. But there have been cases[37] where the actions of a public authority, in permitting pollution of a person's home to the extent where it affected health, have been judged to be contrary to Article 8.

- Article 1 of the First Protocol provides for the protection of property -

  Every natural or legal person is entitled to the peaceful enjoyment of his possessions. No one shall be deprived of his possessions except in the public interest and subject to the conditions provided for by law and by the general principles of international law.

  In determining these authorisations the Agency must prove, in relation to this Article, that by permitting the discharge of radioactivity from the Magnox sites that have not damaged the peaceful enjoyment of a persons property. This has particular relevance to radiation levels. If the public complain that the current radiation levels, on the basis of recent scientific evidence, are unsafe, and the Agency permits these discharges, then if in the near future the public's case is proven to be correct the Agency could be liable to pay compensation to all those affected.

Finally, we have so far discussed the Agency 'acting' in a manner not conforming with the convention. Section 6(6) of the *Human Rights Act* creates a legal right of redress where a "failure" to act by a public authority can be considered to breach the Convention. For example, where the emissions from an industrial site were demonstrated to have an effect on the local population, but the regulatory authority took no action or failed to undertake a proper investigation (in terms of Article 6(1), they

[37] *Lopez Ostra v Spain* (1994) – the construction of a waste treatment plant next to a persons house, which had caused severe local pollution and health problems, was in violation of the persons rights under Article 8.

would be liable.

In determining these applications the Agency must be able to show, both through the writing of their decision document, and if challenged in court, that they had regard to the *European Convention on Human Rights*. In particular, the Agency must demonstrate that it has had regard to all the objections submitted to it, and that these objections have been fairly and objectively investigated.

2.6. The process following the consultation

These applications have been working their way through the system for two years. There is still no clear date for the resolution of this process. In our view -

- given the evidence relating to the uncertainty over the current 'safe' levels of radiation dose;
- given the efficiency/suitability of these plants to generate energy; and
- given the public concerns regarding discharges of radioactivity to the environment,

the Agency must undertake more research work, and dialogue with BNFL, to resolve the issues identified in this report. Also, given the complexity of the objections being made in this report, it would be advisable for the Agency to meet and discuss how they can best progress to the issues raised in order to resolve them.

It is likely that further investigations of the objections submitted by the public will result in new information being produced, both by the Agency and BNFL. In our view this new evidence must also be circulated for public consultation to check its validity. It is also important to ensure that those members of the public who made objections have the opportunity to see that their objections were the subject of investigations by the Agency.

We request that the Agency consider another round of public consultation follow their evaluation/investigation of the objections raised in this and other responses. Also, if the Agency wish, we would be willing to meet and discuss the objections made in this report.

3. Engineering and Economics

This section considers the engineering and economics issues raised in the consultation reports and the BNFL documents. For the most part, these objections relate to those sites where BNFL are proposing to continue energy generation. The objections relating to decommissioning relate to all sites. Documents relevant to the consideration of the arguments listed in this section are provided in Annex 3.

3.1. The economic case and externalities

In relation to the 'justification of practice', the Agency have assessed the economic case presented by BNFL. In our view this assessment is incomplete because:

- It has not provided any assessment of the externalities, either beneficial or prejudicial, for the continued operation to generate power [arguments presented below];
- It has not provided any comparative argument for the efficiency, in terms of radiation releases per unit power generated, for the continued operation of these plants [see section 3.2 below]; and
- There appears to be no serious consideration of the regulatory risks implicit in all operations at nuclear sites – primarily the implications of the OSPAR Convention [see section 3.3 below].

In terms of BNFL's economic assessment, and the analysis of this by Ernst and Young, the most damning flaw is the failure to consider the externalities. If, in accordance with government policy, the polluter is to pay, then we must factor in externalities the represent the value of environmental degradation caused by the operation of the plants. Unless we include these other factors then 'natural capital' that the UK Sustainable Development Strategy seeks to protect and maintain will be degraded.

Likewise, we must re-value the notional value of these plants to GDP. The economist who devised GDP, Simon Kuznets, said in 1934 that,

> *"The welfare of a nation can scarcely be inferred from a measurement of national income".*

Today, even the Office of National Statistics says that,

> *"GDP should not be interpreted as a measure of human welfare".*

The use of alternatives to GDP has not merely been a topic developed by environmentalists. Alternative economic indicators were strongly promoted by Labour in their 1994 environmental policy document '*In Trust for Tomorrow*'. Also, in July 1998, the Parliamentary Environmental Audit Committee also endorsed the need for alternative economic indicators[38].

[38] Sixth Report of the commons Environmental Audit Committee, *The Greening of Government*, HC426-I, Session 1998-9, 1st July 1998.

In order to undertake a proper analysis of the external costs, it will be necessary to gauge the impact of the operation of the Magnox plants, including the reprocessing of fuel. Therefore, BNFL must provide some estimates of the levels of illness and death not only among the human population, but also in terms of wildlife, and the degradation of the natural environment.

Also, when considering the engineering and economic benefits/disbenefits of operation we have to consider the alternatives to providing the energy these stations create. We cannot simply look at the risks of a nuclear operation alone. We have to compare the risks and benefits of nuclear generation to other available technologies. For example:

- Nuclear power is more expensive than other forms of conventional power generation, and is more expensive than some renewables such as wind, tidal and small-scale thermal/photovoltaic solar panels;
- Nuclear power, because of the problems of public acceptability and the costs of generation, is, in the views of the Department of Trade and Industry's unlikely to represent a viable generation option in the future[39];
- In terms of the radioactive emissions, these can be compared in various ways, but the Magnox stations represent the largest emissions of radioactivity per unit of energy generated (see section 3.2 below).

Finally, there are the perceived benefits of nuclear power in lowering the production of carbon dioxide – noted at length in BNFL's justifications for continued operation of the Magnox stations. In our view, this cannot be considered in isolation. Other technologies, as noted above, could have achieved this same result if they too had received billions of pounds of government subsidy for the last fifty years. When considering the validity of nuclear power as a mean of generating power, we also have to take the alternative options, and public opinion, into account.

The Royal Commission on Environmental Pollution's Twenty-Second Report[40] outlines the priorities for lowering greenhouse gas emissions by margins far greater than current government targets. However, RCEP are not strictly pro-nuclear. Whilst accepting that nuclear may be better than fossil fuels from the point of view of climate change, they note that an expansion of nuclear capacity is not possible until a publicly acceptable solution is found to waste disposal. This conditional approach could be difficult for the industry. A recent Eurobarometer survey conclude that a large majority of the European public were very concerned about radioactive waste disposal, and many would prefer to live nowhere near a radioactive waste disposal site[41]. These results, regarding public perceptions of radioactive waste management, must be taken into account by the Agency [see section 2.4].

In any case, it would appear from recent news reports[42] that BNFL have, because of recent problems

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[39] *The Energy Report 1999*, DTI 1999

[40] *Energy – The Changing Climate*, Royal Commission on Environmental Pollution, Twenty-Second Report, Cm4749, June 2000. The summary, and relevant sections of the report on nuclear power, have been reproduced in Annexes A3.4, page A3-13, and A3.5, page A3-22.

[41] *Public Opinion on Radioactive Waste Management in the European Union*, Derek Taylor/Simon Webster, EC DGXI, 1999. This paper is actually data abstracted from Eurobarometer 50.0 – Europeans and Radioactive Waste, January 1999. The DGXI paper is reproduced in Annex A3.7, page A3-29.

[42] Articles in *The Observer's* Business Section, 20/8/00 and 27/8/00. These have been reproduced in Annexes A3.2, page A3-8, and A.3.8, page A3-38.

resulting from their breaches of safety protocols, a potentially damaging cash-flow problem. It would also appear that the proposal to 'safe store' the reactor hulks for over 100 years is being questioned by the Nuclear Installations Inspectorate (NII). This would significantly increase the levels of radioactive discharges and radioactive waste produced as part of the main decommissioning of the plants. But if, as NII appear to believe, that the reactor hulks cannot be maintained for 100+ years, then these increased discharges must be regarded as unavoidable.

If these economic problems continue to manifest themselves over the next year or so, this could jeopardise BNFL's ability to manage these sites and decommission them, or force the management to seek to implement cuts that may affect safety. The issues of BNFL's financial stability must be resolved by the Agency before these applications are granted.

In conclusion, The Environment Agency must direct BNFL to incorporate values for external costs and benefits. For example, there has been a suggestion from the nuclear industry recently that carbon-based energy sources should be taxed as a means of promoting the values of nuclear power[43]. Whilst such values can be credited to the balance sheet for nuclear generation, we must also debit other costs. For example:

- **the damage to species caused by radioactive discharges; or**
- **the loss of economic productivity and the cost to the National Health Service of those who are made ill or die from cancer and other illnesses caused by the radioactive discharges.**

Likewise, the potential for economic difficulties at BNFL, because of the current problems relating to the loss of contracts after their recent safety breaches, must also be investigated before these applications are determined.

Unless BNFL's justification incorporates externalities it cannot the terms of the Basic Safety Standards Directive.

3.2. The generating efficiency of the Magnox plants

In our view, the generating efficiency of the Magnox plants has not been properly evaluated. In terms of justifying practice, the assessment must include an evaluation of the efficiency of generation. This is because the generation of power in a manner that did not represent the most efficient form of operation, in terms of the nuclear sector as a whole, would be unjustifiable. Also, in terms of the fuel cycle, considerations of efficiency must also fuel reprocessing.

The Magnox plants do not produce, in terms of national production, such significant amounts of power that their closure would in any harm UK energy supplies. Before the announcement that Hinkley Point A was to close, Magnox stations produced 8% of electricity in the UK. Hinkley's closure represents a cut of around 19% in Magnox capacity, reducing the national share to around 6.5%. The stations have in any case always been run at a far lower capacity than they are capable of generating

[43] *Nuclear Energy – the future climate*, Sir Eric Ash (Royal Society), conference presentation to the BNES/BNIF Nuclear Congress 1999, printed in *Nuclear Energy*, August 2000; 39/4, 213-216

in order to extend their lifetime[44]. This 20% reduction in capacity took place during the early 1970s when it was realised that corrosion of the core was becoming a problem. Lowering the operating temperature, and hence the efficiency, solved this problem.

The most basic measure of efficiency must be a comparison between the Magnox stations themselves. In terms of how well the station operates this can only really be rated in terms of the levels of radioactive discharges during normal operation. This of figure course, to produce a realistic result, must be weighted in accordance with the station's generating capacity in order to give a comparable result. These values have been calculated and displayed in Table 1:

Table 1: Comparison of Proposed Disposal/Discharge Limits

Plant		Sizewell	Dungen's	Bradwell	Oldbury	Wylfa	Total
Capacity, MWe		420	440	246	434	950	2,490
Drigg Disposal, GBq/y	*Actual*	399.80	147.50	347.70	113.50	263.80	1,272.30
	Comparative	86.3%	-34.4%	176.6%	-48.8%	-45.7%	
Liquid Discharge, GBq/y	*Actual*	12,700	9,900	8,400	2,400	15,110	48,510
	Comparative	55.2%	15.5%	75.3%	-71.6%	-18.4%	
Atmospheric discharge, GBq/y	*Actual*	3,005,851	1,707,751	1,002,291	514,450	120,751	6,351,093
	Comparative	180.6%	52.2%	59.7%	-53.5%	-95.0%	
Total disposal/ discharge, GBq/y	*Actual*	3,018,967	1,717,824	1,011,047	516,983	136,348	6,400,876
	Comparative	179.6%	51.9%	59.9%	-53.7%	-94.4%	

For each of the major disposal/discharge routes (incineration and transfers have been ignored) the 'expected' levels are calculated[45]. The actual figure for the site is then subtracted from the expected, and this is then divided by the expected figure to produce a percentage variance. Finally, to give an idea of the overall efficiency, the same operation is carried out for the site total (but inclusive of incineration and transfers).

It is clear from Table 1 that Sizewell, in terms of radioactive discharges, is the least efficient (180% higher than expected). But Dungeness (52% higher than expected) and Bradwell (60% higher than expected) are also well off the mean level. To give a visual comparison, the total site discharges for all sites, including non-operational sites, is given in Figure 1.

The comparative level of discharge is only one measure of efficiency. In order to provide another, and more all-encompassing, comparative measure we can actually look at the level of radioactive

[44] *Magnox history, current status and future strategy*, C. Smitton. In *Nuclear Energy*, June 2000; 39/3, 171-174. This paper has been reproduced in Annex 3.3, page A3-9.

[45] Expected level is calculated by dividing the total disposal/discharge for all sites (right hand column), by the total generating capacity (2490MWe), and then multiplying by the generating capacity of the site.

Figure 1: Comparison of Total Site Discharges

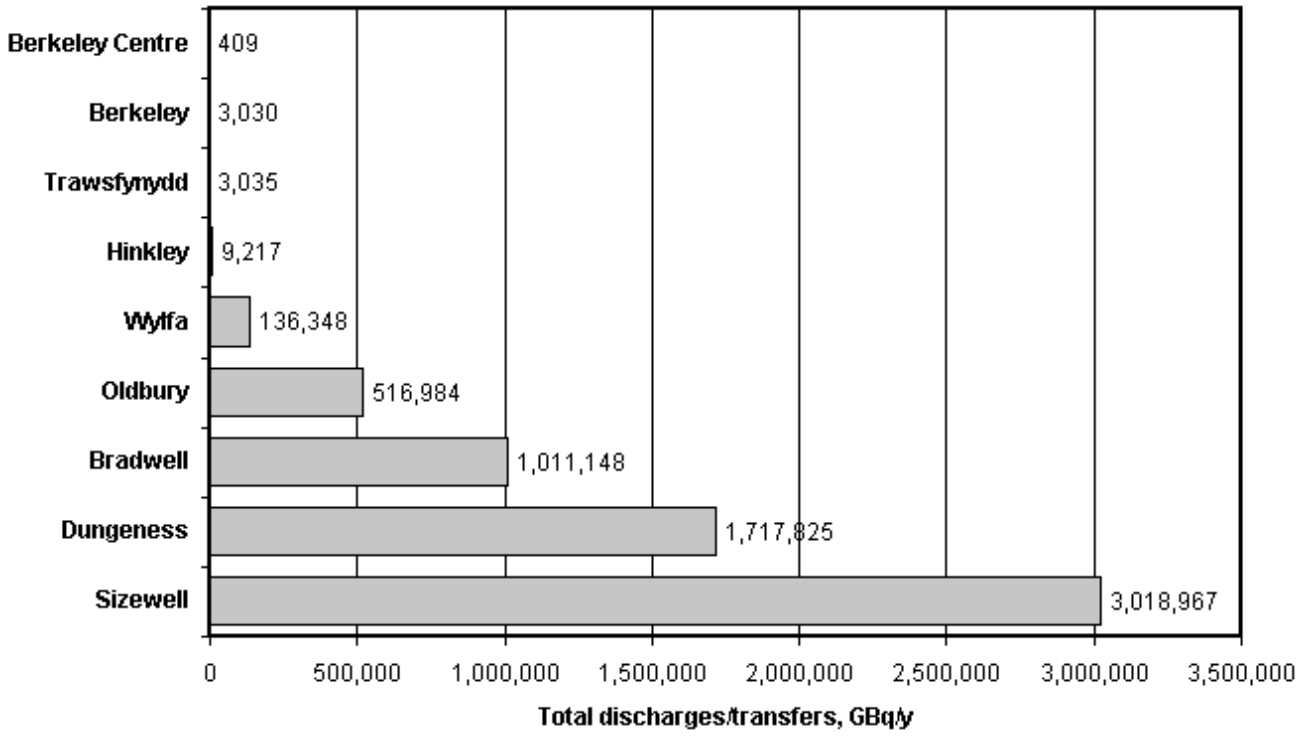
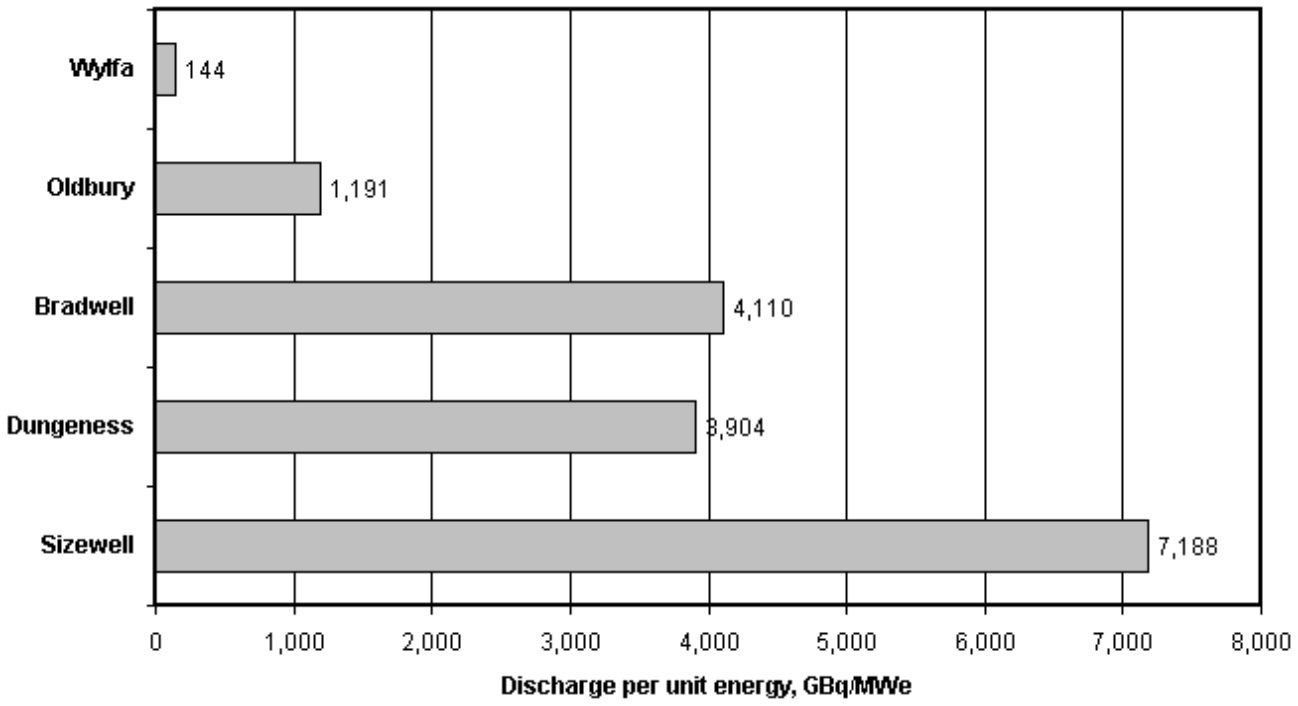


Figure 2: Discharges per Unit of Generating Capacity

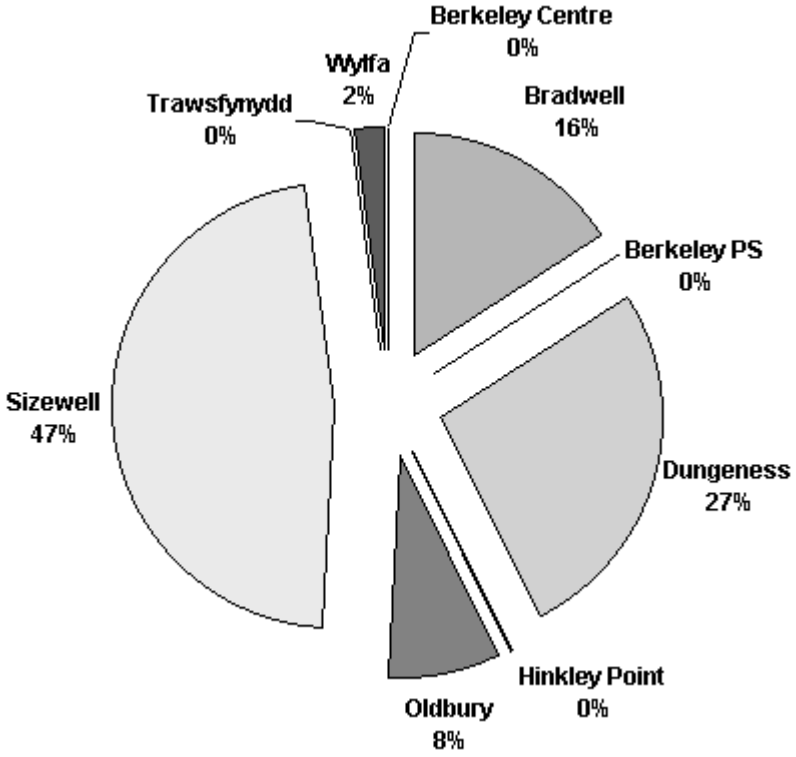


discharge per unit of energy generated. This is calculated by dividing the total disposals/discharges by the station's generating capacity. The results are shown in Table 2, and graphically in Figure 2.

Table 2: Comparison of efficiency as radioactive release per unit energy

Plant	Sizewell	Dungen's	Bradwell	Oldbury	Wylfa
Capacity, Mwe	420	440	246	434	950
Discharges/disposal, GBq/y	3,018,967	1,717,824	1,011,147	516,983	136,348
Efficiency, GBq/MWe	7,188	3,904	4,110	1,191	144
Variance from average, %	117.3%	18.0%	24.3%	-64.0%	-95.7%

Figure 3: Comparison of total site discharges/disposals



Yet again the same three stations – Sizewell, Dungeness and Bradwell – are falling below the average level. Graphically, the direct comparison between sites can easily show which plants could be considered to be operating inefficiency (even without weighting for generating capacity). This is shown in Figure 3 (percentage figures indicate the proportion of the total discharges from all Magnox sites).

In comparing nuclear generation, we should also consider comparisons to other reactor types. When considering a comparison between Magnox reactors, AGR's and PWR's, we need to also have regard for the back-end of the fuel cycle – the reprocessing of fuel at Sellafield. This is because the back-end of the fuel cycle has a significant impact on the efficiency of the reactor type.

Firstly, we can consider fuel usage. It is also possible to look at efficiency in terms of nuclear fuel[46]. Magnox stations generate 120 giga-Watt hours of electricity per tonne of fuel. The AGR reactors generate 600 giga-Watt hours per tonne of fuel – five times more efficient than Magnox. Finally, the Sizewell B PWR generates 1,200 giga-Watt hours per tonne of fuel – ten times more efficient than Magnox.

When considering the back-end, the effects of the Magnox programme are considerable. Magnox fuel is unique, and since the 1960s, it has been reprocessed in a purpose-built building at Sellafield – B205. Whilst the Magnox stations themselves represent a significant source of aquatic discharges, the reprocessing of Magnox fuel represents one of the largest contributions to the discharges from Sellafield.

In figures given to the Environment Council by BNFL[47], B205 represents about 10%-15% of critical group doses due to Sellafield airborne discharges, and 80-90% of critical group doses due to liquid discharges. This is because the B205 reprocessing plant at Sellafield, like the Magnox power stations, was designed to maximise reprocessing capacity rather than minimising environmental discharges. For an equal quantity of nuclear fuel, the plant is far dirtier than the new THORP plant.

Section 3.4 below discusses the procedural imperatives to implement the OSPAR 'Sintra' agreement. But at the practical level, the only way that Britain will meet the need to 'implement a programme of substantial reductions by 2000' (one of the objectives of the Sintra agreement') is to close some or all of the parts of the Magnox programme.

Finally, as these plants become older the level of core corrosion, noted as a problem in the late 1960s, will create ever-greater levels of radioactive discharges – particularly during blow-downs. In our view, permitting these reactors to discharge ever-greater levels of radioactivity is not consistent with current national and European policy. The plant's themselves, because of their old design, are also inherently 'dirty', and therefore to expect reductions or controls through better management is unreasonable. Therefore, we should move to close these plants as soon as practically possible.

In conclusion, from an analysis of the data provided by the Agency and BNFL that there is a large disparity in the operating efficiencies, in terms of power generation levels incurring certain levels of radioactive discharge, that must be considered when evaluating 'justification of practice'. In our view:

- **Sizewell A, Bradwell and Dungeness A should not be permitted to operate for power generation – in our view the level of radioactive discharges cannot be justified by the quantities of energy production;**
- **Given the need to close Building B205 at Sellafield in order to meet the requirement for 'substantial reductions by 2000', the Agency should set a date for closing the Magnox stations within the next two or three years, in order that the complete closure of B205 can be brought forward well before the 2015 (five years early because of the time lag for discharge reductions). This is to allow 10 years for the reprocessing or**

[46] Figures supplied by Greenpeace.

[47] Figures taken from the Environment Council report, *BNFL Stakeholder Dialogue Discharges Working Group Interim Report*, 28th February 2000. See Annex A3.6, page A3-24.

other treatment of the substantial quantity of spent fuel that will arise due to the near simultaneous closure of all the Magnox stations.

3.3. Economic valuations and regulatory risk

In our view the avoidable cost calculations ignore one important element – regulatory risk.

There are three significant sources of regulatory risk:

- Changes to risk estimates for human radiation dose: It is our contention that recent scientific advice confirms that risk estimates for radiation exposure are far too high. If this position is accepted in the near future by the various regulatory agencies then this will significantly increase the costs of decommissioning because worker exposures will have to be closely controlled.
- Changes to risk estimate for ecological impacts: There is recent evidence that the current assumptions about the damaged caused by radiation to ecosystems are wildly optimistic[48]. If the relevant regulators act upon this evidence, then discharges to the environment would have to be severely restricted, with a consequential increase in costs.
- Changes to the regulation of safety and safety cases that might affect BNFL's intended long-term decommissioning plans. If this brings-forward decommissioning then the discounted figures provided by BNFL would be a significant underestimate of the overall costs (this likelihood of this is actually raised in a recent Observer article[49]).

The two factors are genuine regulatory risks options that add costs. However there is one further regulatory risk that may not add costs, but which would not allow the deferral of plant closure – OSPAR's 'Sintra' agreement.

OSPAR requires that Britain, 'implement a programme of substantial reductions by 2000' [see section 3.4 below]. Closing the Magnox reactors would result in a 'significant' cut in discharges, but the period required to close B205 in to meet the OSPAR deadline required that the Magnox reactors close by 2003 to 2004.

This may seem a vague principle, but the process has already started. Not only with the review of the national radioactive waste strategy (Cm2919)[50], but the proposals to vary the statutory responsibilities of the Agency when granting licenses[51], and in the government's ongoing consultation process on meeting the requirements of OSPAR.

In our view the economic assessment, relying heavily as it does no discounted costs, is

[48] *UK Strategy for Radioactive Discharges 2001-2020 – Consultation Document*, DETR June 2000.

[49] Article in *The Observer's* Business Section, 27/8/00. This has been reproduced in Annex A.3.8, page A3-38.

[50] *Review of Radioactive Waste Management Policy – Final Conclusions*, Cm2919, July 1995.

[51] Announced in Chapter 1, paragraph 1.5, of *UK Strategy for Radioactive Discharges 2001-2020 – Consultation Document.*

unrealistic because it does not factor-in the potential regulatory risks. In particular, the imposition of higher standards, and the potential requirement at the governmental level for the early closure of B205 at Sellafield, and hence the premature closure of the Magnox stations.

The Agency must direct BNFL to reassess the economic case, factoring in various scenarios of regulatory change.

3.4. Implementing the OSPAR discharge reductions

The issues of meeting Britain's obligations under the OSPAR Convention are discussed briefly in the consultation reports – in section 3 and 6A. But these sections, nor the Agency's overview of the Magnox programme provided in Annex 1.1 of the consultation reports, provides any meaningful, quantified analysis of the practicalities of meeting OSPAR's Sintra agreement. The Agency may consider this issues to be premature, as the Government has not yet agreed its own strategy, but the Agency has already used OSPAR as the justification for the closure of a discharge to the River Thames[52].

Closing the Magnox reactors will achieve a significant reductions in airborne emissions – which are not strictly the objective of the OSPAR agreements. In order to achieve the reductions under OSPAR it is necessary to drastically reduce liquid discharges, and the only way to do that is closing B205 at Sellafield. This is not as straightforward as it appears. Magnox fuel, because of it's design, must be processed in some way to make it stable for long-term storage. Reprocessing at Sellafield is one option. Therefore, the power stations must close some years before B205 in order that the fuel from the closed reactors can be reprocessed. BNFL's answer to this problem is Magrox fuel, but that is, in our view, not satisfactory (see section 3.7 below). If B205 is closed then discharges are predicted to decrease as follows[53]:

- ^{137}Cs discharges cut by 30% two years later
- ^{129}I discharges cut by 30-50%
- ^{99}Tc discharges cut by 99% five years later
- ^{14}C discharges cut by 70% one year later
- ^{90}Sr discharges cut by 70% five years later
- ^{3}H (tritium) emissions cut by 30%

As can be seen from these figures, to reach the 2020 deadline B205 would have to be completely closed by 2015. The problem is that if the Magnox stations close down there will be a significant quantity of fuel to reprocess. This could take ten or more years, depending on how well the B205 plant functions. Therefore, the Magnox stations themselves must close by 2005 at the very latest. Any slippage in the timetable and the 2005 target may be missed.

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[52] AWE Aldermaston RSA Discharge Authorisation (RSA authorisation ref. BB0523), granted 9th March 2000, entering into force 1st April 2000.

[53] Figures taken from the Environment Council report, *BNFL Stakeholder Dialogue Discharges Working Group Interim Report*, 28th February 2000. See Annex A3.6, page A3-24..

The Government has issued the framework of it's policy[54] to OSPAR before the 2000 deadline for implementation plans. But this contains, apart from statements of principle, no detailed quantified programmes. It is therefore up to the Agency to use its discretion in this matter, in accordance with the principles outlined by the Government in its statement to OSPAR.

In our view it is within the discretion of the Environment Agency to seek large cuts in the discharges from the Magnox plants. The Agency must not wait until the Government has finally made its policy in relation to implementing OSPAR. The delay caused by that delay, and then the period taken to review the authorisations again, could delay the whole process so long that the 2020 target date could be missed.

Finally, the Agency must consider the option of seeking the closure of all Magnox plants by a set date in order to facilitate the processing/treatment of spent fuel at a rate that will allow B205 to completely close by the year 2015. In order to avoid slippage an earlier date would be preferable.

3.5. Need for a closely defined waste management strategy

Meeting the final date for OSPAR is one problem, But in the immediate future, to comply with OSPAR, we must make 'significant reductions' in discharges. Closing all the Magnox plants could achieve a step towards this, and the Agency must consider this option as a means of meeting the requirement for immediate reduction. But the Agency must also implement reductions in the levels of discharge from all sites, especially those that are decommissioning. In deciding how to deal with liquid effluents we should apply the methodology contained within the national waste hierarchy[55], applying the hierarchy and the principle of 'best practicable environmental option' to the liquid effluent stream:

- *Elimination:* Consideration should be given to the segregation of active and non-active wastewater streams in order to reduce the volume of contaminated liquid that must be dealt with.
- *Reduction:* Management and technological measures should be introduced to minimise the use of liquids as part of the treatment process, and measures should be implemented to restrict/reduce the contact between the liquids and problematic radionuclides (i.e., those that are difficult to deal with as part of the treatment process).
- *Recycling:* Efforts should be made to reuse some of the effluent where to is a practical option in order to reduce overall production.
- *Recovery:* This is related to recycling, but is a more technical activity. Rather than seeking

[54] *Report by the United Kingdom on Intentions for Action at the National Level to Implement the OSPAR Strategy with Regard to Radioactive Substances*, DETR, October 1999. This statement has been reproduced in Annex A2.5, page A2-34.

[55] *Waste Strategy 2000*, Cm4693, May 2000.

to develop one large plant for the treatment of waste, consideration should be given to the treatment of the effluent close to the source of production. The reason for this is that once effluent contaminated to a very-low-level is mixed with more highly contaminated effluent it becomes a problem to treat, and merely adds to the scale of the task. Low-level contamination should be dealt with as close as possible to the source to avoid mixing, and then the treated effluent can be recycled to other uses where potable water quality is not a necessity.

- *Disposal:* As in the hierarchy, this should be considered the last and least advisable option.

The Agency must define, as a condition of the authorisation, that BNFL produce an effluent management plan for each of the sites. This must be not a site-wide plan, but a plan that operates on a section by section basis. Only by developing the plan from the bottom up, setting targets for each area of the plant, will it be possible to achieve effective management of active effluents. This is not a reasonable request, and this type of proposal has already been enacted under the recent review of the AWE Aldermaston's RSA authorisation. Unless a strategic approach is taken to effluent management we could simply end up shifting the emission of radioactivity from one media to another – which defeats the entire purpose of '*best practicable environmental option*'.

In conclusion, the Agency must require, by condition, an overall management plan for the production and treatment of radioactive liquid effluents on the site. Such a plan is the first stage of planning the reduction and elimination of liquid effluent discharges to the environment, and should be implemented within a specified timescale as a condition of the authorisation. The principles of the waste hierarchy must be applied to liquid wastes in order to minimise the production of effluent that requires treatment.

For those sites that are in/entering the decommissioning phase, an effluent management plan is extremely important. Decommissioning, whilst leading to large decreases in atmospheric emission, can lead to increases in the discharge of some nuclides to sea. Therefore, BNFL should be required, within six months of the granting of the authorisation, to implement a system of developing new infrastructure, management and controls to ensure that the discharges from decommissioned sites achieve regular targeted reductions in the discharge of certain nuclides. Emphasis should be placed on those nuclides that have a tendency to bioaccumulate, and all alpha-emitting nuclides, to nuclides that decay to alpha emitters within a few years of discharge.

3.6. The legal status of spent fuel

In our view the Environment Agency have failed to regulate the transfer of significant amounts of radioactivity from the Magnox sites – the spent nuclear fuel. The Agency has regarded spent nuclear fuel as a 'resource'. In our view, this is not a legally sound position.

The Environment Agency are required, at licensed nuclear sites, to regulate the disposal of

radioactive materials. Authorisation for the accumulation of materials is not required for sites licensed under *The Nuclear Installations Act*[56]. But, when spent fuel is transported off-site then it requires authorisation. This is because the fuel must be treated, in accordance with past legal cases, as waste.

The Radioactive substances Act contains various definitions:

- '*Radioactive material*' is defined in section 1 of the RSA. Spent fuel meets these definitions, containing both radioactive elements above the de minimis levels in Schedule 1 of the Act, and because it contains substances derived from nuclear fission within it.
- Section 2 of the Act defines 'radioactive waste' as,

  'a substance or article which if it were not waste would be a radioactive material'.
- '*Waste*' is defined in section 47(1) as,

  '...any substance which constitutes scrap material or an effluent or other unwanted surplus substance arising from the application of any process, and also any substance or article which requires to be disposed of as being broken, worn out, contaminated or otherwise spoilt.'
- '*Disposal*' is defined in section 47(1) as,

  '...in relation to waste, includes it's removal, deposit, destruction... or burial...'

But above and beyond the definitions in the RSA, waste has a more wide-ranging meaning as defined in case law. In particular, the Berridge Incinerators case[57], the decision on which was later written into a DoE Circular on waste[58]:

> *'It is of course a truism that one man's waste is another man's raw material. The fact that a price is paid by the collector of the material to its originator is, no doubt, relevant, but I do not regard it as crucial. If I have an old fireplace to dispose of to a passing rag and bone man, its character as waste is not affected by whether or not I can persuade the latter to pay me 50p for it. In my judgement, the correct approach is to regard the material from the point of view of the person who produces it. Is it something which is produced as a product, or even as a by-product of his business, or is it something to be disposed of as useless?'*

This definition was refined further by, but essentially kept the same meaning, in the definition of waste provided in the EC Framework Directive on Waste.

In our view, this sums up the case for whether spent nuclear fuel is a resource or a waste. In terms of BNFL Magnox as the producer, this material is an unwanted, useless, and surplus to the operation of a nuclear power station. BNFL's reprocessing arm – the 'rag and bone man' – may have a use for this material, but in terms of the waste producer this material is waste.

In conclusion, spent nuclear fuel is a 'waste' material. As such, it requires authorisation for transfer away from the Magnox reactor sites to Sellafield. The Environment Agency must perform the necessary updating of the authorisations to include this material within the terms

[56] Section 14(3) of the RSA.

[57] *Berridge Incinerators v Nottinghamshire County Council* (1987)

[58] Paragraph 2.7, DoE Circular 13/88, *Collection and Disposal of Waste Regulations*.

of the draft authorisations. We then we suggest that the new drafts are reissued for consultation as this would represent a substantial variation at each site.

3.7. The implications of changing the composition of Magnox fuel

BNFL have proposed that at Wylfa and Oldbury that a new fuel design – *Magrox* – be introduced into the reactors after 2003. This is a ceramic fuel rather than a metal fuel. In our view, the main objective of this change is to artificially prolong the lives of these two reactors for financial reasons. This is because of the need to meet Britain's obligations under OSPAR, which force the closure of the Magnox reactors in order to permit the closure of B205 at Sellafield.

The proposed change of fuel types sits, interestingly, between the regulatory responsibilities of the Agency and the Health and Safety Executive. HSE's Nuclear Installations Inspectorate would have to receive and approve the safety case for the use of this new fuel before it is loaded into the reactors. However, the use of this fuel is likely to have significant effects on the performance of the reactors, potentially increasing radioactive discharges (for example, by causing more corrosion).

In our view, this change of fuel is such a significant change to the original design that it actually changes the nature of the reactor itself. It would increase the neutron flux density (potentially causing faster ageing of the metals within the concrete reactor vessel). It may also result in an increase in temperature, which may in turn lead to greater erosion/corrosion of the graphite moderator, with the potential to increase beta particulate, ^{14}C and tritium levels. In our view, these changes are so significant that, in terms of the law, they require an environmental statement.

The decision of Mr. Justice Potts in R v SoSE ex parte Greenpeace Ltd[59] considered the issue of environmental assessment. In his view, the THORP plant, including the issuing of pollution control licences, consisted of one development. As permission for THORP had been given before the implementation of the EC Directive on Environmental Assessment it was not therefore subject to the need for environmental assessment.

The same does not apply in this case because the substantial modification of these plants is being promoted today. For the purposes of environmental assessment, any development which fits into a defined class and scale of development, and for which permission was sought after 14th March 1999, are required to submit an environmental statement before 'development consent' is granted.

At issue in the case of R v SoSE ex parte Greenpeace Ltd was whether or not the emissions of radioactive substances were a separate 'development consent' from the construction of the THORP plant. If so did the term 'development consent' also encompass pollution control permits upon which the operation of a development was conditional. Mr. Justice Potts concluded that because the emissions were inseparable from the plant itself, they were one project. As the THORP plant had been given the go-ahead before 1988 it did not therefore require environmental assessment. That situation does not exist here. The scheme to use Magrox fuel is essentially new, and fundamentally

[59] *R v Secretary of State for the Environment and others, ex parte Greenpeace Ltd and another*, All England Law Reports 4 [1994], 382-384. The report of this case is reproduced in Annex A2.3, page A2-10.

changes the nature of the reactors. In our view, it does meet the tests of it being a 'separate project'.

In conclusion, there are legal argument for why the proposed change in fuel should be subject to an environmental statement. The Environment Agency must request an environmental impact statement detailing the potential changes to radioactive discharges as a result of the change in fuel. If this is not forthcoming then the Agency must not rely in any way on the introduction of Magrox fuel at a future date when determining these applications.

3.8. Managing the decommissioning of sites

Decommissioning raises many problems. Not only what should be done with the radioactive material produced through decommissioning, but also how to manage the impacts decommissioning creates. These applications raise three significant issues.

Firstly, given the uncertainties in the short-term regarding the health effects of low-level radiation, no material should be clears for 'free release' until the situation regarding dose and health effects has been resolved. Once the material has left the site, it is very difficult to control where it is used. Likewise, the fact that material is leaving the site means that there is a risk of other highly active material becoming accidentally mixed into the free release stream. The recent incident in Sheffield when ^{238}Pu was accidentally put through a reclamation furnace[60] should serve as a warning. Likewise, the various incidents over the past two years where depleted uranium has ended up in scrap yards[61].

Secondly, how does the Agency account for the wide variation in the 'decommissioned' operational limits? Does this imply that BPM is not evenly applied at the three sites given that all the sites are broadly similar in terms of design. The Agency should be seeking to bring the discharges that result from decommissioning down to similar levels.

Finally, how is the Agency addressing the issue of ^{14}C disposal problems. These were identified in a recent paper from the UKAEA[62]. The particular problem identified by the UKAEA is that Drigg, where this material should be disposed of, currently has a capacity of 1.5TBq ^{14}C remaining – 0.05TBq/year for it's remaining lifetime. However, just one small reactor, the Windscale No.1 Pile, contains 6.9TBq ^{14}C, exceeding Drigg's limit by 4.6 times. Each Magnox reactor contains hundreds of tonnes of contaminated graphite.

Various options have been identified for dealing with ^{14}C. This generally involves some form of high-temperature incineration. But this is not straightforward because the graphite contains level of Wigner energy – energy fixed into the carbon lattice by neutron bombardment over the operational lifetime of the reactor. When this material is heated to 50°C to 80°C above the operating temperature of the reactor it continues to heat itself until it burns in a self-sustaining reaction. Therefore, new concepts in incinerator design have been considered to deal with the excess energy this will create. The concerns in terms of the Agency's role is that all these schemes, be it direct incineration or the use of a high-

[60] *Plutonium released in Sheffield*, 'News' section in *Nuclear Energy*, August 2000; 39/4, 201

[61] *Depleted Uranium on scrap heaps*, Simon Bowers and Paul Brown, *The Guardian* 21st August, 2000.

[62] *Management of UKAEA graphite liabilities*, M. Wise, *Nuclear Energy*, August 2000; 39/4, 249-257.

temperature lasers, will all produce radioactive off-gases. This could potentially lead to damaging effects on the surrounding environment given the long half-life of ^{14}C and high bioavailability of carbon compounds.

In conclusion:

- **We request that, for the time being, the Agency refrain for giving permission for the 'free release' of materials produced from decommissioning operations. If however they do not do this, then we demand that procedures and monitoring systems are introduced to ensure that the material that is released for recycling will have an extremely low probability of containing any material above free release limits.**
- **We re request that the Agency give an account as to why the levels set for decommissioning at the various non-operation sites vary to such an extent. The Agency must explain how this can happen if BPM is being evenly at all sites, and what will be done to ensure that all sites, including reactors to be close in the future, meet similar low discharge levels.**
- **Finally, the Agency must have regard to the problems of ^{14}C disposal, and the potential impacts if this material is incinerated during the process of decommissioning. In particular, BNFL should identify options and contingencies, together with their relative environment impacts, for how the hundreds of tonnes of graphite arising during decommissioning work will be dealt with.**

4. Environmental Impacts

This section considers information in relation to the environmental impacts of radioactive discharges, their assessment, and their acceptability. Documents relevant to the consideration of the arguments in this section are provided in Annexes 1, 2 and 3.

4.1. Conflicts between radioactive discharges and the protection of species

In our view the position of the Agency with regards to the protection of wildlife, expressed in section 7.2 of the Agency's consultation document, is incompatible with the law on species protection. This is because, by accepting that the discharges will result in the death of certain individuals within a species, then if that species is protected under the Habitats Directive a breach of the law will have taken place.

The EC Habitats Directive[63] lays down certain minimum standards of protection for certain habitat types, and for certain species of flora and fauna. This Directive was enacted into UK law by the *Conservation Regulation 1994*[64]. The regulations correctly enact the main parts of the Directive. However, there is a question with regard to Article 12(d) of the Directive in relation to the 'deterioration' of habitats (rather than just the 'destruction' catered for in the regulations). In principle though, the failure to implement provisions relating to the 'deterioration' mean that the Habitats Directive itself gives legal force to Article 12(d) through the '*direct effect principle*'.

Various parts of the applications documentation[65], and Annex 7.2 of the Agency's consultation documents, admit that wildlife will be damaged by these discharges. This will result in some fatalities. This position is in turn based upon the position of ICRP stated in 1977[66] and in 1991[67]:

> *The standard of environmental control needed to protect man to the degree currently thought desirable will ensure other species are not put at risk. Occasionally individual members of non-human species might be harmed, but not to the extent of endangering whole species or creating imbalances between species.*

This position, in our view, is no longer tenable. Recent evidence suggests that species within the natural environment are far more exposed than humans. Recent studies[68] demonstrate that the

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[63] *Council Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora*, 21st May 1992 – EC Directive 92/43/EEC. Relevant extracts are provided in Annex A2.1, page A2-2.

[64] *The Conservation (Natural Habitats &c.) Regulations 1994*, SI. 1994/2716. Relevant extracts from the regulations are provided in Annex A2.2, page A2-4.

[65] For example, Oldbury BNFL documentation section 15, question 4.22, or Sizewell BNFL documentation section 13, question 9 ('ecology' section) and section 17, question 4.26.

[66] *ICRP Publication 26*, ICRP 1977.

[67] *ICRP Publication 60*, ICRP 1991.

[68] *Environmental effects of radionuclides – observations on natural ecosystems*, D. Copplestone et. al., *Journal of Radiological Protection* 2000; 20, 29-40. This paper is reproduced in Annex A1.2, page A1-23.

damaging effects of radiation exposure on wildlife can be detected at levels three orders of magnitude below the 1mGy d^{-1} level (currently believed to be the point at which no effects should be observed). Research on the effects at higher radiation levels[69], associated with fallout from the Chernobyl accident, show increased mutation rates in a species of bird two to ten times higher than in control the groups. Evidence also suggests that the mutations were affecting the fitness of the bird, and that the transmission of mutations was also taking place via the germline (so endangering future generations).

At the policy-level too, concern is being expressed. Senior staff within the Environment Agency have expressed concern about the current framework for the radiological protection of the environment[70], and have suggested possible changes to current regulatory systems. This paper also accepts that the criteria that the protection of humans ensures the protection of wildlife is 'increasingly being challenged'. Other commentators have also suggested that the ICRP's position is no longer valid[71]:

> *Past reliance on the International Committee on Radiological Protection's statements to the effect that if man is adequately protected from environmental radioactivity, then other organisms can be assumed to be adequately protected as well, no longer seem adequate… The US Department of energy has already proposed a primary dose rate standard, and is currently establishing models designed to estimate dose rates from commonly monitored quantities, such as radionuclide concentrations in soils, air and water.*

So at the practical and policy level, there is clearly a move against the position if the ICRP, based on more detailed studies which show damaging effects to ecological systems at dose rates well below the levels previously thought acceptable.

The implications for the discharge of radionuclides in relation to these applications are significant:

- The position of both BNFL and the Agency with regard to the acceptability of ecological impacts is no longer tenable;
- There is evidence that current discharge levels will have damaging effects on certain areas of wildlife; and
- If we take a holistic view, then the discharges resulting from the reprocessing of Magnox fuel associated with the continued operation of the Magnox reactors will have a wide ranging impact on wildlife that cannot be excluded from the cost–benefit equation.

In our view, the possible impacts on land-based species, but in particular sea-based species is unacceptable. However, in terms of the Habitats Directive, in our view the approval of these discharges could be deemed to be unlawful. Members of protected species may be killed as a result of these discharges – and offence under the 1994 regulations. It is also very likely that the accumulation of radionuclides in the environment will have a more damaging (but perhaps sub-lethal)

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[69] *Fitness and germline mutations in barn swallows breeding in Chernobyl*, Ellegren et. al., *Nature*, 9/10/97; 389, 593-596. This paper has been reproduced in Annex A1.2, page A1-102.

[70] *A system for radiological protection of the environment: Some initial thoughts and ideas*, R.J. Pentreath, *Journal of Radiological Protection* 1999; 19/2, 117-128. This paper has been reproduced in annex A1.2, page A1-44.

[71] Radioecology: relevance to the problems of the new millennium, F. Ward Whicker, Journal of Environmental Radioactivity 2000; 50, 173-178. This paper has been reproduced in Annex 1.2, page A1-17.

impact on the fitness and breeding capabilities – a breach of Article 12(b) of the Directive. Of particular concern are those species at the top of the aquatic food chain such as otters, seals, dolphins, porpoises and whales.

Whilst legal processes exist under the 1994 regulations to review potentially damaging schemes being authorised under planning or other legislation, no such provisions exist in the regulations for the review of authorisations under the *Radioactive Substances Act*. Therefore, it is up to the Environment Agency itself to ensure that in authorising these discharges, that the terms of the regulations and the Directive are not breached.

The 'bottom line' is that the Agency must demonstrate that the discharge of radioactivity from a lawful activity that damages protected species, such as nuclear power generation, could not have been otherwise avoided. This in turn brings us back to a justification argument. As noted in sections 2.3 and 3.2 earlier, is clear that the poor performance of the ageing Magnox power and reprocessing plants cannot be justified in terms of environmental impacts when compared to the levels that could be achieved should existing new technology be applied. Therefore, as the discharges were not unavoidable, an offence may have taken place.

In conclusion:

- **There is a growing body of evidence that the damaging and lethal effects of radiation on wildlife can be demonstrated at levels far below those suggested as 'acceptable' by ICRP and others;**
- **The position of ICRP, that the protection of humans will ensure the protection of wildlife can be shown to be invalid – and is being criticised by other policy makers and commentators;**
- **The acceptance that certain members of certain species will be killed as a result of the discharges from the Magnox plants means that, if the species concerned were protected, the discharges that resulted in that death would be unlawful if it could not be proven the discharges were unavoidable;**
- **The sub-lethal effects of discharges that lead to illness or loss of general/reproductive fitness, resulting from the deterioration of the environment, are also a relevant consideration in terms of Article 12(d) of the Directive and must be assessed by the Agency; and**
- **It is up to the Agency and BNFL to prove that the discharges from the Magnox plants will not cause damage or death to protected species, or that if such effects do occur that these impacts could not reasonably be avoided.**

These issues must be resolved before the Agency can determine these applications, or the decision of the Agency will be open to challenge.

4.2. The modelling of atmospheric discharges

Section 2.5.1 of Annex 7.1 of the Agency's consultation document makes various assertions about the role of the R91 dispersion model. In our view, for certain types of emission, the R91 is not an adequate model to properly predict the dispersion of radionuclides, and hence the exposure of the public to radiation from atmospheric discharges. In terms of the Magnox plant's discharges, the atmospheric route is the single largest emission of radionuclides – roughly 10 times greater than disposal to Drigg and 40 times greater than disposals to sea[72].

The mathematics of dispersion modelling has developed from the 1970s in response to the need to provide a quantified assessment of industrial emissions. Over the last 20 years models have become more complex, to incorporate features such as building effects, terrain and meteorology. But the models used by the Agency and BNFL are the R-91[73]/R-157[74] models developed by the National Radiological Protection Board during the 1970s in order to assess the effects of radionuclide dispersion from deliberate and accidental releases.

Over the last ten years, both in Europe and in the USA, the basis of dispersion modelling has been refined produce more accurate dispersion models simulating more closely common meteorological phenomena. In the USA, the principles behind R-91/R-157 were developed on a different course to produce the ISC model – currently the US Environmental Protection Agency's standard model for regulatory assessment. In the UK there has never been any serious emphasis on modelling pollution – with the exception of the *Clean Air Acts* – until the implementation of '*integrated pollution control*' (IPC) under the *Environmental Protection Act 1990*. Even then, there have been no specific guidelines on modelling – it's left up to the applicant in each case to use the form of modelling they consider most appropriate.

One of the Environment Agency's predecessors, Her Majesty's Inspectorate of Pollution[75] (HMIP) were involved modelling development work, and commissioned work on behalf of the Department of the Environment[76]. The reports commissioned by HMIP also considered the comparative performance[77] of the main dispersion modelling systems:

- ADMS (Atmospheric Dispersion Modelling System);
- ISC (Industrial Source Complex, which comes in short term – ST- and long term – LT – versions); and
- R-91 (named after the NRPB report number R-91 that described it).

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[72] These figures are based on the proposed authorisation levels for the older Magnox plants

[73] *A Model for Short and Medium Range Dispersion of Radionucleides Released into the Atmosphere*, R.H. Clarke. NRPB report R-91, 1979.

[74] *Models to Allow for the Effects of Coastal Sites, Plume Rise and Buildings on Dispersion of Radionucleides and guidance on the Value of Deposition Velocity and Washout Coefficients*, J.A. Jones. NRPB report R-157, 1983.

[75] Note, HMIP administered not only IPC, but they also had responsibility for radioactive substances.

[76] *Validation of the UK-ADMS Dispersion Model and Assessment of its Performance Relative to R-91 and ISC using Archived LIDAR Data*, HMIP 1996. DoE Report No. D0E/HMIP/RR/95/022

[77] Section 2, ibid. Relevant extracts from the report are provided in Annex A3.1, page A3-2.

The report produced by HMIP states, in relation to the effectiveness of the R-91 model[78]:

> *It has been recognised for some time that the basic R-91 type approach has a number of limitations. Fundamentally, the model does not fully recognise the variation with height of both mean flow and turbulence within the boundary layer and the crucial role of the boundary layer height. Thus R-91 predicts similar rates of vertical spread for surface releases and a release near the centre of the atmospheric boundary layer. However, in convective conditions actual rates of spread near the centre of the atmospheric boundary layer are very much greater.*

The conclusion in the executive summary of the report also states:

> *On the basis of these comparisons, it was concluded that the ADMS model provides a more prediction then R-91 and ISC-ST of the location and magnitude of the maximum ground-level concentration in convective conditions for elevated sources (typically above 30 metres in height). Support for this conclusion came both from the case study where the RASCAL [Rapid Scanning LIDAR – Light Detection and Ranging] system had been set up to measure maximum ground-level concentrations and from other case studies where plume size and height had been measured in the earliest stages of plume development. This improved performance could be traced to better-founded parameterisation of the of the atmospheric boundary layer in ADMS compared to that in R-91/ISC and to the more realistic models of plume dispersion and plume rise in ADMS. A particular feature was the failure of the 'Pasquill Stability Category' approach (the basis for characterising the state of the boundary layer in older models) to diagnose the substantial convective activity at the height of the plume which would have been expected according to current understanding.*
>
> *The ADMS results also indicated that, on average, the differences between predicted and observed maximum ground level concentrations in conditions similar to those investigated is unlikely to be more than a factor of two. This is acceptable for most practical purposes and is unlikely to be bettered by other modelling methods. Here, the 'average' is taken over a sufficient number of trials (terms an 'ensemble') to smooth out the inherent variability in this type of measurement arising from atmospheric turbulent fluctuations with a variety of timescales. This factor-of-two performance was not met by the R-91 type models. Support for this conclusion came from the average discrepancy between data and predictions of the size and height of plumes upwind of the point of maximum ground level concentration. In addition, for the case where the RASCAL measurements did not provide maximum ground-level concentrations, ADMS predicted not only the ensemble-average condition but also the expected scale of the fluctuations in concentration. The differences between measurements and predictions were fully consistent with this scale and often within a factor of two.*
>
> *The above conclusions imply that it is inappropriate to rely on R-91 type models for sources higher than about 30 metres in convective conditions. They lead to the recommendation that ADMS, or an equivalent model which is already validated and based on modern boundary-layer parameterisations, is preferred in such conditions.*

The Magnox reactor plants contain a variety of emission points, each with different characteristics of discharge volume, velocity, temperature and vector. For this reason there must be a more detailed effort to model discharges based on realistic emissions rather than averaging the site into one source. Also, when considering terrain, we have to consider the height above the modelling baseline.

[78] Section 2.2.2, ibid. See Appendix 5.8.

There will be vents where the effective emission height (that is, incorporating the effect of thermal buoyancy) is higher than 30 metres. It could be claimed have been inadequately assessed because of the faults in the R-91 model identified within the validation report for ADMS.

The accuracy of the model is not the only consideration. Its method of use is also significant. There are three aspects of model use that must be considered, and which have not been commented upon in the consultation document:

- The use of terrain data to produce a variable receptor height, and to consider the varying effects on the movement of the plume between the undulating ground level and the plume. There has been some significant work in this area recently, in relation to the use of ISC model[79] (which is also be applicable to the use of ADMS).
- The data produced by the Agency should have involved the use of short-term *and* annual averages in order to produce a representative set of average and peak exposure levels.
- No consideration has been given to the effects of surface roughness on the emission of pollutants from low-levels, and in particular the trending of discharges from coastal sites. Dispersion changes radically in near ground conditions. Friction from the surface slows dispersion, and leads to a rapid increase in pollutant concentration. Likewise, the changes in daily air flows at coastal locations, together with the more aberrant changes in air temperature and humidity, can lead to the increased fallout of pollutants within particular areas inland of the release point.

There is also no information as to the averaging times used in running the model. Models can average over short period of time – 10 minutes is often the shortest period – up to periods of one year. It is important to include annually based meteorological data in order to produce a representative exposure at the receptor point based upon the changing trends during the seasons. It is also not clear how the emission parameters for pollutants have been characterised. The assumptions made relating to the volumes, speeds and temperature of emissions has considerable effects on the model's output.

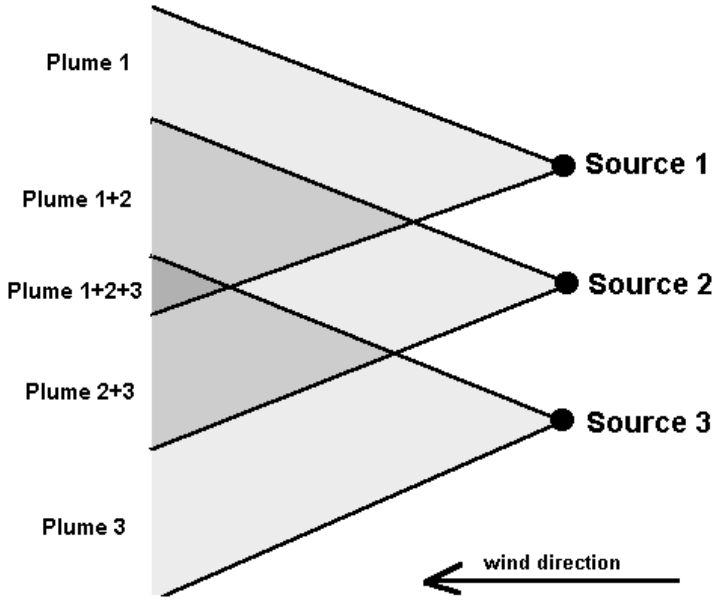
The ordinary use of a two-dimensional R-91 model (*x* and *z* axes – i.e. distance and height) is questionable as it will underestimate doses in the near field (up to 10 kilometres). It appears as if the model assumes the whole site to be one source. However, there are a multitude of releases spread over a large area. This broadens the area affected by emissions near to the site, and up to a distance of ten or twenty kilometres. On a site such as this, the emissions at different locations should be modelled separately, and then the total exposure calculated as the sum of the 'overlapping' plumes (see figure 4 below). This is because the combination of plumes can lead to a higher exposure than the predicted peak-plume centreline exposure.

It is possible on a site such as this, where there are many sources of pollution, that simple modelling could underestimate exposure, particularly when considering the effects of annual variations on meteorological trends. It would appear that this model is a short-term averaging model that does not consider annual trends, only peak trends, assessed on the assumptions about plume dispersion.

[79] *Dispersion Modelling of Dioxin Releases from the Waste Incinerator at Avonmouth, Bristol, UK*, JP. Basham and I. Whitwell, June 1998. Published in *Atmospheric Environment* no.36 (1999), 3405-3416.

The use of a two-dimensional model can also underestimate the impacts of meteorological effects, particularly those caused in highly stable (that is, very low level of vertical mixing) atmospheric conditions. For example the effects of subsidence inversion (common in hilly areas) and inversion layers which trap emissions and significantly increase exposure. The use of the R-91 based model also means that the acknowledged effects of changing boundary layer and stability conditions with distance are not considered.

Figure 4: The effect of multiple point sources



The accuracy of the model chosen in order to assess regulatory compliance is very important. In terms of the Agency's statutory guidelines, the powers of the Agency must be exercised in accordance with certain objectives. In relation to this case, the Agency must[80]:

> *operate to high professional standards, based on sound science, information and analysis of the environment and of processes which affect it*

This statutory duty cannot be discharged if the authorisation proceeds on the basis of the dispersion models currently being used to assess impacts. Given that better procedures for quantifying the impacts of airborne pollution on the environment exist, the Environment Agency cannot claim to be using best practice, or the best assessment procedures, in determining this authorisation.

Finally, the emphasis on these applications, and the Agency's analysis on them, is on the radioactive impacts. However, radioactive elements also have a toxicological impact. This has not been assessed by the Agency. In my view there should be an analysis presented of:

- Significant non-radioactive pollutants that have implications for health, and/or pollutants (mainly, those with a demonstrable effect on physiology or which are known mutagens) that could combines with radioactive emissions to produce synergistic or additive effects in the promotion of ill-health and cancer.

[80] See Appendix 5.2.1, paragraph 9(iv)

- The distribution of radioactive emissions in terms of their mass distribution (rather than activity) in order to assess the potential for chemical toxicity (for example, uranium or plutonium).

The chemical toxicity of many radioactive materials has been known for some time. The Royal Commission on Environmental Pollution's Sixth Report commented on the toxicity of plutonium[81]. There has also been concern expressed about the potential neuro-toxicological effects of uranium following new studies in relation to the use of uranium-tipped conventional weapons. There have also been studies that show certain workers exposed to radiation, such as uranium mineworkers, have significantly higher risks than other workers in the same environment if this is associated with exposure to chemical-based hazards such as smoking. The emissions of chemical pollutants, for example from the industrial processes and combustion plants on the site, is also therefore significant and should be assessed alongside the radioactive component in the risk equation.

For those industrial processes that are regulated under Part I of the *Environmental Protection Act 1990* (EPA) – of which there are a number on these sites – the precedence of authorisation is clearly established. Section 28(2) of the EPA clearly states that where the same process is regulated under Part I of the EPA and the RSA, the EPA authorisation will not be binding on the operator where there is conflict. In my view any radioactive emission that has a toxicological impact must be assessed in terms of its non-radiological effects given that the provisions of the ordinary non-radioactive authorisation process – the EPA – does not bind the operator.

In terms of these applications, the significant source of chemical pollutants will be the discharge of radioactivity to the sea, and the incineration of waste. Whilst there has been some discussion in relation to the chemical additives present in the liquid discharges, there has been no detailed assessment of the chemical impacts of incineration. Of particular concern are the effects of the main combustion gases, and the organic compounds produced during/after of combustion such as dioxins and volatile organic compounds (VOCs).

In conclusion:

- **The modelling of exposures from the emissions of radioactive materials from the Magnox reactors is overly simplistic. The use of older 'standard' models has been a matter of convenience, not an exercise in producing a meaningful quantification of the effects of the releases from these sites. If we compare the modelling processes undertaken for these sites they fall far-short of the standards ordinarily practised at comparable non-nuclear site (for example, IPC regulated integrated chemical facilities, or large ferrous/non-ferrous metal plants). The Agency must require that a more realistic modelling of emissions from the site is carried out before determining the applications.**
- **The use of an R-91/R-157 derived model is completely inadequate for the modelling of emissions from these sites. Likewise, the method of it's use is open to criticism. The use of an R-91 model to assess emissions which are thermally buoyant or are emitted from around 30 metres is completely inappropriate, given HMIP's condemning**

[81] Paragraphs 66 to 77 and 322, Royal Commission on Environmental Pollution's Sixth Report, *Nuclear Power and the Environment*, Cmnd.6618, September 1976.

analysis. Given that other models are commonly available, the use of these older, outdated models indicates an unwillingness on the part of BNFL to consider the effects of emissions using more accurate analysis techniques. The modelling of emissions needs to be completely reviewed and reassessed, using a modelling protocol that is scientifically sound for the emissions and dispersion being studied, and which is acceptable to the public.

- **Unless there is an exercise to determine the significance of the chemical, as opposed to the radiological effect of discharges, the risk of the site will not be adequately assessed. In terms of the HSE's *Tolerability of Risk* report, and other reports (such as those cited earlier), it would not be valid to exclude one facet of risk from the assessment of this site. The ordinary chemical toxicity of radioactive compounds, and the radiological risk, are inseparable in a process that authorises the release of those compounds.**

4.3. Evaluating the impact of discharges and decay products

There are three main objections in relation to the setting of discharge levels:

- The setting of discharge levels does not take account of the hazards created by radioactive decay;
- The setting of discharge levels has no regard to the chemical form of the radionuclide, and hence the bioavailability of the compounds released;
- No regard is had to the effects of past discharges.

Firstly, when setting the permitted level for certain radionuclides, the Environment Agency should have regard to the types of radioactivity emitted. The arguments presented in section 5 of this report stress the likely significance of higher-LET radiation – α and β particles – in creating cancer and other illnesses. Therefore, the Agency should seek to restrict α- and β-emitting radionuclides to very low levels. But the decay of radionuclides can involve many steps, so increasing the impact:

- A β-emitting radionuclide can, in one or two steps, turn into an α-emitting radionuclide. For example, ^{241}Pu, a β emitter with a half life of 14.4 years, ^{241}Am, an α-emitter with a half-life of 432 years.
- An α-emitting radionuclide can give rise to a series of α-emitting radionuclides. For example, ^{222}Rn, an α-emitter with a half-life of 3.8 days, decays into ^{218}Po, an α-emitter with a half life of 3.1 minutes.
- A β-emitting radionuclide can give rise to other β-emitting radionuclides. For example ^{90}Sr, a β emitter with a half life of 28.8 years, decays into 90Y, a β emitter with a half life of 2.7 hours.

The most significant steps in radioactive decay series are where long-half-life (days or years) radionuclides decay into short-half-life (minutes or seconds) radionuclides. This is because the decay of the atom twice in a short space of time will increase the likelihood of damage to the same area of tissue, so creating a greater risk of mutation (the so called, 'second event theory'). Half-life also determines the capacity of a radionuclide to enter the food chain. Short-lived radionuclides released

Table 3: The Main Decay Series Producing α-Emitting Radionuclides

Curium-243 Series

$^{243}Cm \rightarrow \alpha$ (29.1 years)
↓
$^{239}Pu \rightarrow \alpha$ (24.1 thou. y.)
↓
$^{235}U \rightarrow \alpha$ (703 M yrs)
↓
$^{231}Th \rightarrow \beta$ (1.1 days)
↓
$^{231}Pa \rightarrow \beta$ (32.8 thou. y.)
↓
$^{227}Ac \rightarrow \beta$ (21.8 years)
↓
$^{227}Th \rightarrow \alpha$ (18.7 days)
↓
$^{223}Ra \rightarrow \alpha$ (11.4 days)
↓
$^{219}Rn \rightarrow \alpha$ (4.0 seconds)
↓
$^{215}Po \rightarrow \alpha$ (1.8 m. secs.)
↓
$^{211}Pb \rightarrow \beta$ (36.1 minutes)
↓
$^{211}Bi \rightarrow \alpha$ (2.1 minutes)
↓
$^{207}Tl \rightarrow \beta$ (4.8 minutes)
↓
^{207}Pb (stable)

Plutonium-241 Decay

$^{241}Pu \rightarrow \beta$ (14.4 years)
↓
$^{241}Am \rightarrow \alpha$ (432.2 years)
↓
$^{237}Np \rightarrow \alpha$ (2.1 M yrs)
↓
$^{233}Pa \rightarrow \beta$ (27.0 days)
↓
$^{233}U \rightarrow \alpha$ (159.2 thou. y)
↓
$^{229}Th \rightarrow \alpha$ (7.3 thou. yrs.)
↓
$^{225}Ra \rightarrow \beta$ (14.9 days)
↓
$^{225}Ac \rightarrow \alpha$ (10.0 days)
↓
$^{221}Fr \rightarrow \alpha$ (4.9 minutes)
↓
$^{217}At \rightarrow \alpha$ (32.3 m. secs.)
↓
$^{213}Bi \rightarrow \beta$ (45.6 minutes)
↓
$^{213}Po \rightarrow \alpha$ (0.0 m. secs.)
↓
$^{209}Pb \rightarrow \beta$ (3.3 hours)
↓
^{209}Bi (stable)

Thorium-232 Decay

$^{232}Th \rightarrow \alpha$ (14,050 M yrs)
↓
$^{228}Ra \rightarrow \beta$ (5.8 years)
↓
$^{228}Ac \rightarrow \beta$ (6.2 hours)
↓
$^{228}Th \rightarrow \alpha$ (1.9 years)
↓
$^{224}Ra \rightarrow \alpha$ (3.7 days)
↓
$^{220}Rn \rightarrow \alpha$ (55.6 seconds)
↓
$^{216}Po \rightarrow \alpha$ (0.1 seconds)
↓
$^{212}Pb \rightarrow \beta$ (10.6 hours)
↓
$^{212}Bi \rightarrow \beta$ (1.0 hours)
↓
$^{212}Po \rightarrow \alpha$ (0.3 u. secs.)
↓
^{208}Pb (stable)

Curium-242 Decay

$^{242}Cm \rightarrow \alpha$ (162.8 days)
↓
$^{238}Pu \rightarrow \alpha$ (87.8 years)
↓
$^{238}U \rightarrow \alpha$ (4,468 M yrs)
↓
$^{234}Th \rightarrow \beta$ (24.1 days)
↓
$^{234}Pa \rightarrow \beta$ (6.7 hours)
↓
$^{234}U \rightarrow \alpha$ (245.5 thou. y)
↓
$^{230}Th \rightarrow \alpha$ (75.4 thou. y.)
↓
$^{226}Ra \rightarrow \alpha$ (1,600 years)
↓
$^{222}Rn \rightarrow \alpha$ (3.8 days)
↓
$^{218}Po \rightarrow \alpha$ (3.1 minutes)
↓
$^{214}Pb \rightarrow \beta$ (26.8 minutes)
↓
$^{214}Bi \rightarrow \beta$ (19.9 minutes)
↓
$^{214}Po \rightarrow \alpha$ (0.2 m. secs.)
↓
$^{210}Pb \rightarrow \beta$ (22.3 years)
↓
$^{210}Bi \rightarrow \beta$ (5.0 days)
↓
$^{210}Po \rightarrow \alpha$ (138.4 days)
↓
^{206}Pb (stable)

Promethium-147 decay

$^{147}Pm \rightarrow \beta$ (2.6 years)
↓
$^{147}Sm \rightarrow \alpha$ (106,000 M y)
↓
^{143}Nd (stable)

from reactors do not have much chance to assimilate into plant and animal life, and so the major risk is from direct radiation or inhalation. Longer-lived radionuclides have the opportunity to be incorporated into plant and animal life prior to decay – so making it more likely that they will decay within the tissues of plants and animals cause far greater damage than external radiation. This is assisted if the chemical form or behaviour of the radionuclide can be easily assimilated into living organisms – for example radionuclides such as tritium and ^{14}C.

Secondly, the setting of limits does not have regard to the chemical form of the radionuclides discharges. A good example of a radionuclide with high bioavailability is tritium. (^{3}H). As an atom with a similar chemical behaviour to ordinary hydrogen, it can be release as:

- a gas ($^{3}H_2$);
- as heavy water ($^{3}H_2O$);
- as a hydroxyl radical that may bind with many other compounds ($O^{3}H$); or
- as a more complex hydrocarbon, perhaps as the result of combustion, incineration or biological digestion (e.g. benzene $C_6{}^{3}H_6$, or methane $C^{3}H_4$)

But whatever it's chemical form, if the compound that is release has a high bioavailability, or through the action of bacteria or plant metabolisms can be reacted upon to increase its bioavailability, then the radionuclide will have a significantly greater impact on humans, agriculture and wildlife. For example, the action of bacteria can add organic compounds to metal ions such as strontium (which can then be metabolised in animals in the place of calcium) or caesium (which can then be metabolised in plants and animals in place of potassium).

Finally, all assumptions on doses for critical groups are based upon modelled values, in turn based upon projections of future releases. This takes no account of the accumulation of past discharges, and more significantly the potential for the reservoir of radionuclides held in marine or river sediments to be transferred back to the land or re-suspended by the wind. In terms of radiological impact, it is possible to argue that the resuspension of deposited material has as significant an impact as new discharges from the plants themselves. Various studies have associated increased levels radionuclide in sediments with localised increases in cancer[82] [83] [84].

At various points, the Agency and BNFL draw attention to the 'background' exposure of the UK population in comparison to the discharges from nuclear plants. In our view, this is misleading since these figures are aggregated from exposures across the UK population. If we compare the UK annual average 'involuntary' radiation dose, then the UK average is 2,244μSv y^{-1}, of which 0.01% is the result of the nuclear industry. By 'involuntary' radiation dose, this is all sources of radiation that are

[82] *Death rates from leukaemia are higher than expected in areas around sites in Berkshire and Oxfordshire*, Busby & Scott Cato, *British Medical Journal* 19/4/97; 315, 309. This paper is reproduced in Annex A1.2, page A1-118.

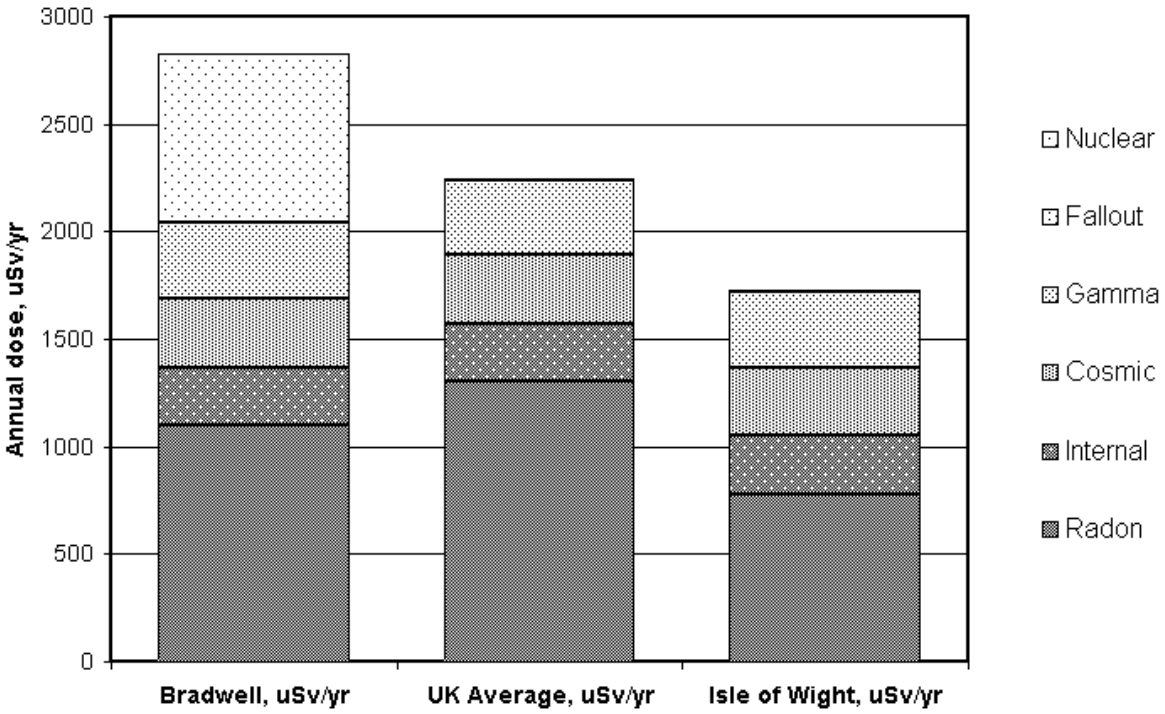
[83] *Cancer Mortality and Proximity to Hinkley Point Nuclear Power Station 1995-1998: Summary of Green Audit Study Findings*, Green Audit 2000. Available online at http://www.llrc.org/hinkley.htm

[84] *Proximity to the Irish Sea and Leukaemia Incidence in Children at ages 0-4 in Wales from 1974-1989 – First Report of the Green Audit Irish Sea Research Group*, Busby et. al., Green Audit Occasional Papers 98/4; August 1998. Available online at http://www.llrc.org/child_leuk_wales.htm

Table 4: A comparison of 'background' doses

Source:	Bradwell[85], μSv y^{-1}	UK Average[86], μSv y^{-1}	Isle of Wight[85], μSv y^{-1}
Radon	1,100.0	1,300.0	780.0
Internal	270.0	270.0	270.0
Cosmic	320.0	320.0	320.0
Gamma	350.0	350.0	350.0
Fallout	4.0	4.0	4.0
Nuclear	783.0	0.3	0.3
Total	**2,827.0**	**2,244.3**	**1,724.3**

Figure 5: Comparison of 'background' radiation doses



(note, the 'fallout' figures, and the UK/Isle of Wight 'nuclear figures are so small they do not appear on the chart)

[85] The 'nuclear' figure for Bradwell is the Agency's dose assessment from Table 7.2 of the Bradwell consultation document. Although this figure includes direct radiation, it does not include historic discharges. Other figures come from the NRPB reports cited (85) below.

[86] These figures are compiled from two report: *Radiation Exposure of the UK Population: 1993 Review*, Hughes and O'Riordan, NRPB report R263, 1993; and *Ionising Radiation Exposure of the UK Population: 1999 Review*, Hughes, NRPB Report R311, 1999.

beyond the control of ordinary people. Occupational and medical doses are not included in these figures as these represent 'voluntary' doses. But, if we take the case of Bradwell, incorporating direct radiation, then the figure is 2,827μSv y^{-1}, of which 28% is the result of the nuclear industry. By comparison the Isle of Wight, on of the lower areas for dose in the UK, has a total dose of 1,724μSv y^{-1}, of which 0.02% is the result of the nuclear industry. As a whole, the nuclear element of Bradwell's background radiation levels is over 1,500 times higher than the Isle of Wight, and over 2,000 times the UK Average.

The proportion of the annual dose received by those living near nuclear power stations is dominated by the releases from the plant. Therefore, it is only prudent that the Agency have regard not only to the releases directly from the plant, but also the local background radiation that has been enhanced by the plant's historic discharges. If, as is our case (see section 5 below), current radiation risk levels care too high then the historic reservoir of radionuclides contained in land and marine/lake silts will become far more important as a source of radiological risk.

In conclusion, the potential for radioactive decay to give rise to more, or more hazardous radionuclides should be taken account of by the Environment Agency when setting discharge limits. Rather than setting limits on a general numerical basis, the limits should be based on a risk assessment considering:

- **The likelihood of radioactive decay producing more hazardous radioactive emissions;**
- **The potential for the creation of radionuclides whose chemical form has a high bioavailability to living organisms; and**
- **The potential for the decay of longer-lived radionuclides to produce short-lived radionuclides, thereby increasing the likelihood of tissue damage should those radionuclides be taken-up in living organisms.**

At the same time steps should be taken to discover and if possible control the chemical form of the discharges to ensure that they as a low bioavailability and environmental mobility. If necessary, the Agency should required the installation of treatment plants in order to modify or control the most undesirable releases of radionuclides, in particular tritium.

Finally, the Agency, in assessing doses from future discharges and in setting levels to control doses, must have regard to the impact of the historic legacy of radionuclides in the local environment. Where there is an excess of certain nuclides in the environment with the potential to increase radiation doses then the future discharge of that radionuclide must be reduced.

5. Human Health Impacts

The whole basis of these applications being 'safe', and therefore suitable for the Environment Agency to permit, relies on a series of studies upon which the current safety standards are projected. It is our view, based upon recent scientific studies, that the data on which current safety standards are based is invalid. Not only is the statistical basis of the information incorrect, but the biological processes assumed to lead to ill-health cannot take account of other biological processes induced by radiation that have recently been discovered.

The statutory responsibilities of the Environment Agency, and national policy guidance on sustainable development and environmental risk, require that the Agency have regard to scientific evidence on the issues involved in determining applications for pollution. The Agency is required to evaluate this new evidence before determining these applications. This section outlines the case on why the current risk estimates are incorrect, and Annex 1 provides copies of relevant papers on the issues.

5.1. Recent research on radiation and health and the consideration of scientific uncertainty

There are many instances where the occurrence of ill-health around nuclear installations has been attributed to other causes than the radioactive discharges from the plant. For example, the transmission of viruses through the mixing of populations resulting from the construction of large industrial facilities in rural areas. The industry and the primary 'authority' on radiation, the National Radiological Protection Board (NRPB), have not yet questioned the validity of their own models, and the data on which they are based. This approach is unscientific, and in terms of the public's perceptions is directly attributable to the close associations between those who provide official advice on the effects of radiation and the nuclear industry.

Recent evidence, from studies in the UK and elsewhere, raises questions about the current 'accepted' radiation risk models. In particular, questions have been raised in relation to the statistical data and biological processes on which these risk models are based. There are currently four main areas of divergence from the accepted models of NRPB and ICRP:

- The reliance on the existing risk factors is questionable given recent evidence of the statistical inconsistencies in the dataset on which they are based. The methodology assumes that the dataset represents a homogeneous population. Recent research indicates that the data is not representative of a homogeneous population. [see section 5.2 below]
- The existing risk factors do not take account of the difference qualitatively between 'high-' and 'low-LET' radiation – between radiation of high and low ionising potential. Recent studies by NRPB in relation to 'low-level radiation' are actually concentrating on 'low-LET' radiation. They do not specifically consider the effects of low-levels of high-LET radiation. Recent evidence suggests that very low-levels of high-LET radiation have a qualitatively higher impact on health than current risk estimates suggest. [see section 5.3 below]
- The current risk estimate do not take account of more complex cellular effects induced by radiation. In particular the implications of 'genomic instability', and the 'bystander effect'.

These effects have significance not only in terms of the impacts to the health of those currently exposed to radiation, but through mutations of the germline to future generations too. [see section 5.4 below]

- Recent evidence relating to the impacts of radiation from the Chernobyl accident suggest that in utero exposure to low-levels of radiation results in a disproportionate risk of ill-health in the early years of life. These effects are not considered within current risk estimate because the levels of environmental radioactivity produced by the Chernobyl accident outside the former Soviet Union were not considered significant. Evidence from within the former Soviet Union also suggests that, in the light of recent studies, risk estimates generally are too low. [see section 5.5 below]

In response to these challenges to the orthodox position of the acceptability of low doses of radiation, the Environment Agency must impartially assess this new evidence to see if it has a bearing on it's regulatory functions. Whilst NRPB may represent the government body charged with advising on matters of radiological protection, the NRPB's advice cannot remove the obligations put upon the Agency under their statutory obligations to have regard to the best scientific evidence.

If the Agency proceed in determining these applications without clarifying the validity of the risk factors on which the Agency's judgement is based then those opposed to the granting of these applications may seek a review of the Agency's decision.

5.2. Criticisms of Japanese A-bomb survivor-based risk factors

The reliance on the existing risk factors is questionable given recent evidence of the statistical inconsistencies in the dataset on which they are based. The methodology assumes that the dataset represents a homogeneous population. Recent research indicates that the data is not representative of a homogeneous population.

Since the 1950s the survivors of the atomic bombs dropped on Hiroshima and Nagasaki have been monitored in order the better understand the effects of radiation upon human health. Since the 1960s, all 'official' models of radiation risk have been based upon the results of these studies. Any results or models that did not correspond to the data from these studies were not accepted as being valid. Now the official models themselves are under challenge. This began with the occurrence of health effects at radiation levels not predicted by the a-bomb survivor based models. More recently, studies have re-evaluated the data on which the official models are based, and have indicated that there are systemic errors in the datasets upon which the models are based.

Concern about the health impacts of low-level radiation surfaced in the early 1980s. Studies examining the occurrence of certain types of adult and childhood cancer found that there were 'clusters' of illness concentrating around certain nuclear sites. These results were dismissed by the government and health officials at the time because they did not conform to the accepted dose–effect models.

The relevance of the observed health impacts near nuclear installations was dismissed, most notably

within work commissioned by the NRPB[87], but the lack of alternative models at this stage meant that some caution was exercised:

> *Childhood leukaemia has been reported to be increased in communities living near a number of nuclear sites in the United Kingdom... The studies have all indicated that it is most unlikely that radiation doses arising from the release of radioactive materials into the environment could have contributed to any increase in the leukaemia incidence in local communities... In the absence of any other causative agent, however, there remains some concern that the radiation doses and risks of leukaemia have been underestimated.*

Following on from this report, there emerged a number of papers that both confirmed the existence of cancer clusters around nuclear installations, and that sought to challenge the claims that these clusters were radiation-induced by advancing alternative theories. The most prominent of these has been the 'population-mixing hypothesis'. This claims that the risks of childhood cancer were not due to radiation, but rather the demographic changes resulting from large infrastructure projects such as power stations[88].

The population-mixing hypothesis is still being used today as an explanation as to why cancer-clusters occur where current radiological or toxicological models cannot explains the effect. Recent papers attribute half of the cancers around nuclear installations to population mixing[89]. Indeed, Muirhead's recent paper reviewing the incidence of cancer around nuclear installations[90] seeks to reinterpret past studies. For example, Muirhead notes the absence of studies outside the UK demonstrating a correlation between low-level radiation and cancer incidence. This position can be easily refuted by looking through the body of literature that does exist. There have been studies showing no effect, but some of those studies, such as Jablon's 1991 study across US states[91], accept that the lack of observed effects is due largely to the restrictions that source data impose. But other studies in the US have found evidence of clusters near nuclear facilities, such as Hatch and Susser's study around Three Mile Island[92].

Positive correlations implication radiation as the causative agent have also been found in France[93],

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[87] *The risk of childhood leukaemia near nuclear establishments*, J.W. Stather et. al., NRPB Report R-215, January 1988. Sections of this report are reproduced in Annex A1.2, page A1-200

[88] *Cancer near potential sites of nuclear installations*, Paula Cook-Mozaffari et. al., The Lancet, 11/11/89; 1145-1147. This paper is reproduced in Annex A1.2, page A1-197. See also *Geographical variations in mortality from leukaemia and other cancers in England and Wales in relation to proximity to nuclear installations 1969-78*, Cook-Mozaffari et. al., *British Journal of Cancer* 1989; 59, 476-485.

[89] *Quantifying the effect of population mixing on childhood leukaemia risk: the Seascale cluster*, Dickinson and Parker, British Journal of Cancer 1999; 81/1, 144-151.

[90] *Childhood cancer and nuclear installations: a review*, C.R. Muirhead, Nuclear Energy 1998; 37/6, 371-379. This paper is reproduced in Annex A1.2, page A1-78.

[91] *Cancer in populations living near nuclear facilities: A survey of mortality nation-wide and incidence in two states*, S. Jablon et. al., Journal of the American Medical Association 20/3/91; 265/11. 1403-1408. This paper is reproduced in Annex A1.2, page A1-184.

[92] *Background gamma radiation and childhood cancer within ten miles of a US nuclear plant*, Maureen Hatch and Mervyn Susser, International Journal of Epidemiology 1990: 19/3, 546-552. This paper is reproduced in Annex A1.2, page A1-190.

[93] *Incidence of leukaemia in young people around La Hague nuclear waste reprocessing plant: a sensitivity analysis*, Viel and Pobel, Statistics in Medicine 1995; 14, 2459-2472. This paper is reproduced in Annex A1.2, page A1-143.

and these studies have continued to show effects even when subjected to more detailed analysis[94]. New evidence is also emerging from studies in the UK looking at nuclear research[95] and nuclear power facilities[96], and the impacts of the Chernobyl accident[97] [98]. But despite the challenges to, and inconsistencies in, both the population-mixing hypothesis and the official risk models[99], the NRPB and others[100] continue to promote a population-mixing solution rather than reassess their own models to consider the deficiencies recent evidence exposes.

Apart from the disparity between observed effects and predictive models, the other great challenge has been to the 'homogeneity' of the data on which the official dose models are based. This comes from two sources:

- Questions about the homogeneity of the population itself, raised especially in relation to recent studies of the human genome; and
- Questions about whether the source data for current risk models is representative of the population.

Work by NRPB itself suggests that genetic variability does result in sections of the public – perhaps 5% – having a far higher susceptibility to damage from radiation than the rest of the population[101]. But this, according to NRPB, is not significant from the point of view of radiological protection. But there is no clear evidence that NRPB have considered this evidence in relation to the effect that genetic variability might have in relation to past and future discharges of radioactivity from nuclear plants.

There have been challenges to the validity of bomb-survivor data for some time. This has often related to the mode of their exposure being unrepresentative when considering the health implications of radioactive discharges. But more recently, the quality of the bomb-survivor data itself has been called into question – most prominently by Stewart and Kneale. A detailed re-evaluation of

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[94] *Case control study of leukaemia among young people near La Hague nuclear reprocessing plant: the environmental hypothesis revisited*, Pobel and Viel, British Medical Journal 11/1/97; 314, 101-106. This paper is reproduced in Annex A1.2, page A1-120.

[95] *Death rates from leukaemia are higher than expected in areas around nuclear sites in Berkshire and Oxfordshire*, Chris Busby and Molly Scott Cato, British Medical Journal 2/8/97; 315, 309. This paper is reproduced in Annex A1.2, page A1-118.

[96] *Cancer Mortality and Proximity to Hinkley Point Nuclear Power Station 1995-1998: Summary of Green Audit Study Findings*, Green Audit 2000. Available online at http://www.llrc.org/hinkley.htm

[97] *Excess of other cancers in Wales*, Chris Busby, British Medical Journal 22/1/94; 308: 268. This paper is reproduced in Annex A1.2, page A1-176.

[98] *Increases in Leukaemia in Infants in Wales and Scotland Following Chernobyl: Evidence for Errors in Statutory Risk Estimates*, Busby and Scott Cato, Green Audit. Occasional Papers No 98/2, June 1998. Available online at http://www.llrc.org/infant_leukaemia_post_chernobyl.htm This paper has been recently revised and published in *Energy and Environment* 2000; 11/2, 127-139

[99] For example – *Cancer in the offspring of radiation workers*, Alexander, Busby/Scott Cato and Stewart, *British Medical Journal* 30/5/98; 316, 1672-1673. This paper is reproduced in Annex A1.2, page A1-87.

[100] For example – *The Seascale cluster: a probable explanation*, Richard Doll, *British Journal of Cancer* 1999: 81/1, 3-5. This paper is reproduced in Annex A1.2, page A1-65.

[101] *Genetic heterogeneity in the population and its implications for radiation risk: Report of the NRPB Advisory Group on Radiation*, Documents of the NRPB 1999; 10/3. Relevant extracts from this report are reproduced in Annex A1.2, page A1-73.

the source data collected from observations of bomb survivors[102] has shown that the population represented in the source data is not homogeneous. There are significant numbers of old and young persons missing from the dataset. It is also likely that radiation-related illnesses in the population were misdiagnosed between 1945 and the beginnings of the studies in 1950. This means that certain cancers, particularly leukaemia amongst those genetically sensitised to radiation, have been excluded from the source data.

All-in-all, Stewart and Kneale's work shows significant systematic flaws in the official methodologies and models for radiation risk. This must lead to a re-assessment of the basis of dose–response models.

In recent years, studies have also evaluated the health records of radiation workers to try and find additional data to corroborate the bomb-survivor datasets. This, potentially, could provide a valuable new insight into the potential health impacts of low-level radiation. But recent studies[103] [104] suggest that dosimetry practices from the 1950s until the late 1980s may have masked the impact of low-level radiation amongst this group. This is because:

- Dosimetry practices resulted in dosimeters being changed at a rate where low-level radiation doses would not have registered – doses were incurred although the dosimetry recorded no exposure; and
- Even where dosimetry recorded low doses, below certain levels these doses were routinely recorded as zero – thus excluding another trance of low-level doses to certain workers.

These errors in dosimetry mean that the population of radiation workers monitored over the past fifty years, irrespective of how representative the demographics of this group are when compared to the rest of the population, were routinely exposed to low-levels of radiation that were not recorded. Therefore, the use of this dataset for examining the effects of low dose radiation, in a mode far more akin to populations exposed to radioactive discharges, is limited.

In conclusion:

- **Observed incidence of certain cancers surrounding nuclear establishments cannot be explained by current risk models. Whilst they is always a possibility of an unknown cause, the failure of the radiological protection establishment in the UK and elsewhere to re-evaluate and justify their own models in the face of mounting evidence confirms the reliability of these models, and the position of those who support these models, as tenuous.**
- **With regard to the population-mixing explanation for these observed health effects,**

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[102] *A-bomb survivors: factors that may lead to a re-assessment of the radiation hazard*, Alice Stewart and George Kneale, *International Journal of Epidemiology* 2000; 29, 708-714. This paper is reproduced in Annex A1.2, page A1-10.

[103] *Recording of external radiation exposures at Oak Ridge National Laboratory: implications for epidemiological studies*, Wing et. al., *Journal of Exposure Analysis and Environmental Epidemiology* 1994; 4/1, 83-93.

[104] *Evaluation of annual external radiation doses at values near minimum detectable levels of dosimeters at the Hanford nuclear facility*, Richardson et. al., *Journal of Exposure Analysis and Environmental Epidemiology* 2000; 10, 27-35. This paper is reproduced in Annex A1.2, page A1-35.

this theory can only be given credence provided that at no point are the data on which conventional dose–response model are based are proven incorrect. Our position is that there is sufficient evidence to question the basis of current dose–response models, and therefore the 'importance' of the population-mixing hypothesis decreases. Viruses do have a causative effect in the promotion of cancer, but there is a question as to whether this acts upon it's own, or whether the effects of radiation induce processes at the cellular level in which a virus may represent the last stage.

- **Studies of genetic variability demonstrate that the population cannot, in its entirety, be treated as homogeneous. The effects of *heterogeneity* on risk models, and in the excess of illness that can be assumed to arise from radioactive discharges, must be considered within the Agency's risk estimates when determining these applications.**
- **The only other significant source of exposure data – radiation workers in the nuclear industry – also contains systematic errors due to dosimetry practices that may not give a representative set of data on the impacts of low-level radiation exposure. The use of this data to supplement the bomb-survivor datasets is unlikely to provide a qualitative improvement to the risk estimates for populations exposed to low-level radiation.**
- **The work by Stewart and Kneale demonstrates the shortcomings in the datasets on which the official risk models are based. The implications of this research must be clarified before the Agency proceed to determine these applications.**

5.3. Dose equivalence and the impacts of 'low-LET' and 'high-LET' radiation

The existing radiation risk models do not take account of the difference qualitatively between 'high-' and 'low-LET' radiation – between radiation of high- and low-ionising potential. The use of dose equivalents by the Agency is therefore too crude a system to effectively gauge the impacts of radioactive discharges on human health and the environment.

The determination of 'absorbed dose' is based upon assessing the 'linear energy transfer' (LET) from the interaction between different types of radiation and the tissue it ionises. Electromagnetic radiation, such as X-rays, γ-rays and cosmic rays, have a low ionising potential and so are classed as 'low-LET' radiation. Particles have a higher impact depending upon their mass. β particles have low mass, but produce higher energy transfers than electromagnetic radiation. Neutrons have a higher energy transfer than β particles. The particles with the greatest mass, and hence the highest LET, are α particles.

The discharges from nuclear power stations are dominated by radionuclides that decay producing β and/or γ radiation. But quantities of α emitters are discharged directly, and are also produced through the decay of other radionuclides.

When calculating dose equivalence (doses expressed in Sieverts) the methodology involves weighting the contribution from different types of radiation qualitatively to produce a single unified figure. But new research suggests that α radiation has a far more complex interaction with the tissues

they pass through than the current methodology considers (this is detailed in section 5.4 below). Therefore the 'quality factors' used to weight the individual contributions are inappropriate for radiation with a higher-LET.

Reassessing the relative importance of radionuclides and the radiation they generate could have significant impacts on current policies for the regulation of radioactive discharges. There may have to be far stricter standards for α-emitters. However, the role of pervasive radioactive pollutants, such as tritium, could also lead to significant changes. Tritium, a β emitter, has been implicated as a likely contributor to a number of health effects[105], but the nuclear industry do not accept this data.

The controversy surrounding low-level radiation involves a debate about the effects of these different types of radioactivity. Those who maintain that current radioactive discharges cause health impacts cite the impacts of low levels of high-LET radiation as being one of the main contributory factors. There have also been a number of published papers that reflect public concern by questioning the whole methodological approach of those who regulate exposures to radioactivity[106].

The response of those charged with investigating the health impacts of radiation have been mixed. Recent studies by the NRPB[107] in relation to 'low-level radiation' were actually concentrating on 'low-LET' radiation. They do not specifically consider the effects of low-levels of high-LET radiation. Therefore, in attempting to respond to the concerns raised by the public, the NRPB have not answered the concerns legitimately raised by the public. Proposed changes to the current system of dose regulation by NRPB/ICRP[108] also fail to address the public concerns, and so there appears to no immediate change from the main advisory body.

The position of the NRPB may, however, be becoming more isolated. Work by the Medical Research Council (MRC) on high-LET radiation has produced a rather different interpretation of the impacts of radioactive discharges[109], far nearer the case made by concerned members of the public. Whilst the ICRP/NRPB consultations on changes to the current system of dose regulation make-reference to this work, it is dismissed because of a lack of causative proof. This of course is contrary to the precautionary principle.

In conclusion, the basis on which doses are assessed as part of regulatory processes are open to question. New evidence suggests that both the biological mechanisms involved in cell irradiation, and the qualitative impacts of different types of radiation, are not properly quantified within the current dose equivalence methodology. The current methodologies also

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[105] *Tritium: The overlooked hazard*, Ian Fairlie, *The Ecologist* Sept./Oct. 1992; 22/5, 228-232. This paper is reproduced in Annex A1.2, page A1-178.

[106] *Cancer risk of low-level exposure*, Marvin Goldman, *Science* 29/3/96; 271, 1821-1822. This paper is reproduced in Annex A1.2, page A1-129.

[107] *Risk of radiation induced cancer at low doses and low dose rates for radiation protection purposes*, Cox, Muirhead et. al., Documents of the NRPB 1995; 6/1. Relevant extracts from this document are reproduced in Annex A1.2, page A1-157.

[108] *Control of low-level radiation exposure: time for a change?*, Roger Clarke, *Journal of Radiological Protection* 1999; 19/2, 107-115. This paper is reproduced in Annex A1.2, page A1-56.

[109] *Radiation Roulette*, Rob Edwards, *New Scientist* 11/10/97. This paper is reproduced in Annex A1.2, page A1-97.

mean that some radionuclides that are currently considered as a low hazard may actually be far more prominent in terms of the initiation or development of cancer. In particular, the pervasive radionuclides produced by the nuclear industry such as tritium. The Environment Agency must demonstrate, given the recent evidence to the contrary, that current equivalent dose methodologies are suitable for use in order to evaluate health impacts. Unless the Agency are able to prove themselves the adequacy of the current dose methodology the Agency will not be able to demonstrate that the impacts predicted from the proposed discharge levels are valid.

5.4. The need to consider complex cellular mechanisms in response to radioactivity

The current risk estimate do not take account of more complex cellular effects induced by radiation. In particular the implications of 'genomic instability', and the 'bystander effect'. These effects have significance not only in terms of the impacts to the health of those currently exposed to radiation, but through mutations of the germline to future generations too. The consideration of cellular-level effects also means that the role of radiation in illnesses other than cancer must be considered.

Traditionally damaged cells were assumed to die. Also, it was assumed that damage was only limited to those cells directly affected by radiation. There have been a number of recent reviews that have cast doubt on these assumptions[110], and about the effects of radiation at the cellular level in general. One of the most wide-ranging reviews is that of Nussbaum and Köhnlein[111]. Their 1994 review highlights the inconsistencies between the assumptions in dose–response models and the results of epidemiological and medical studies. In particular they highlight:

- The likelihood that for certain types of radiation, at certain levels, the dose–response effect is not linear;
- That prolonged exposure to radiation does not reduce risk;
- That the relative effectiveness for medical X-rays and γ radiation does not conform to the effects predicted by dose models;
- The role of free radicals, created by ionisation, that may contribute to the observed non-linear dose–response effects (bystander effects);
- The continued disparity between dose models and the excesses of illnesses that have been observed in human populations exposed to radiation.

More recent research has begun to quantify some of these impacts.

The concept of the 'bystander effect' has emerged recently not only in relation to the effects of radiation, but also in relation to the effects of certain chemical compounds. The basis of the bystander

[110] For example, *Cancer risk of low-level exposure*, Marvin Goldman, Science 29/3/96; 271, 1821-1822. This paper is reproduced in Annex A1.2, page A1-129.

[111] *Inconsistencies and open questions regarding low-dose health effects of ionising radiation*, Nussbaum and Köhnlein, *Environmental Health Perspectives* 1994; 102/8, 656-667. This paper is reproduced in Annex A1.2, page A1-164.

effect is that the communication channels between cells can be disrupted, and this can create damage not only to the cell receiving radiation, but also adjacent tissues. Research has identified that the number of cells affected by radiation is larger than the total number of cells affected by traversing α particles[112], and that,

> *…studies at the gene expression level indicate that similar signalling pathways are induced in bystander cells that are not traversed by an* a *particle as in traversed cells, and that biological effects in cell populations are not restricted to the response of individual cells to the DNA damage they receive.*

Work by Nagasawa and Little has advanced the role of the bystander effect further[113]. They not only observed a non-linear dose–response relationship at very low dose levels, but also,

> *The frequency of mutations induced by a single* a *particle traversing the nucleus of a cell was nearly fivefold at the lowest fluences studied. The data are consistent with the conclusion that the enhanced efficiency of each nuclear traversal at low particle fluences is the result of mutations arising in non-irradiated, bystander cells.*

The effect of genomic instability may also produce disproportionate effects in comparison to the predictions of the orthodox dose–response models. Genomic instability was first discovered in 1992. A detailed review of genomic instability by Morgan et. al. in 1996 looks at the multiplicity of cellular effects that may be initiated by both low- and high-LET radiation. They conclude,

> *Exposure to radiation can lead to cancer, and one of the hallmarks of the cancer cell is the inherent instability of its genome... The mechanisms underlying genomic instability are certain to be complex, as the precise molecular changes and sequences of intervening steps leading to genomic instability remain largely unsolved... Radiation may initiate the events leading to the induction of genomic instability by the deletion of genes controlling stability, by the induction of genes simulating instability and/or by activation of endogenous cellular viruses. Alternately, genomic instability may be independent of induced DNA damage and may involve non-nuclear targets, such as those involved in signalling cascades. There is no reason, however, to assume these events are mutually exclusive.*

The review of the science of genomic instability by Rob Edwards[114] clearly demonstrates that while there is research that shows reproducibility of these findings, NRPB, as the body charged with evaluating the impacts of radiation on the UK population, have failed to take a lead in the debate. Whilst the staff of the MRC raise concerns regarding the '*pollution of the human gene pool*', NRPB reported dismiss the implications of this research by stating that '*there is no proof that genomic instability leads to cancer or other diseases*'. However new research from Belarus is indicating that the contamination resulting from the Chernobyl accident has led to significant increases in mutation

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[112] Intercellular communication is involved in the bystander regulation of gene expression in human cells exposed to very low fluences of alpha particles, Edouard et. al., *Radiation Research* 1998; 150, 497-504. This paper is reproduced in Annex A1.2, page A1-89.

[113] *Unexpected sensitivity to the induction of mutations by very low doses of alpha particle radiation: evidence for a bystander effect*, Nagasawa and Little, *Radiation Research* 1999; 81/1, 3-5. This paper is reproduced in Annex A1.2, page A1-68.

[114] *Radiation Roulette*, Rob Edwards, *New Scientist* 11/10/97. This paper is reproduced in Annex A1.2, page A1-97.

rates amongst the general population[115]. Furthermore, increased levels of germline mutations – mutations that carry-over between generations – have been identified. There is evidence that there have been increases in leukaemia resulting from the Chernobyl accident (see section 5.5 below), but the full effects of the Chernobyl accident will not be readily perceptible for another ten years when the true level of solid cancer causation can be projected. This may, at last, provide the qualitative field data to prove that increases in mutation rates due to higher environmental radiation levels can be linked to increases in malignant and non-malignant diseases.

In conclusion, recent scientific research suggest that there may be other processes taking place than those assumed by orthodox dose models when radiation impacts a cell. In particular, that the effects of irradiation may initiate a sequence of biochemical changes that result not only in cancer but other illnesses. These findings cast serious doubt on the efficacy of current radiation risk models.

The Environment Agency must investigate,

- **the implications of research into the bystander effect for the traditional radiation risk models, and the likelihood that such processes could lead to health impacts at dose levels many times smaller than those currently suggested; and**
- **the implications of genomic instability, not only in terms of the malignant but also the non-malignant health effects, on the current regulatory systems for nuclear plants;**

...before proceeding to determine these applications. Unless the Agency can prove that this new research has no bearing on their role as a regulator of radioactive discharges to the environment, then the Agency must act in a precautionary manner and restrict discharges to levels where the risks are two orders of magnitude below current risk estimates (this being the likely level of error – see section 5.6 below).

5.5. Increased risks resulting from in utero exposure to low-level radiation

As noted in a *Nature* editorial[116], the Chernobyl accident, whilst unfortunate, has given science a completely new test-bed to confirm or invalidate our current theories regarding radiation, health and the environment. As expected, leukaemia has increased initially in response to the fallout from the accident. Over the next ten years, the appearance of the solid cancers will provide new data on the levels of radiation that cause ill health. But already, from a number of studies, there is sufficient evidence to estimate that radiation risk estimates are incorrect.

Recent evidence relating to the impacts of radiation from the Chernobyl accident suggests that in utero exposure to low-levels of radiation results in a disproportionate risk of ill-health in the early

[115] *Further evidence for elevated human minisatellite mutation rate in Belarus eight years after the Chernobyl accident*, Dubrova et. al., *Mutation Research* 1997; 381, 267-278. This paper is reproduced in Annex A1.2, page A1-106.

[116] *Chernobyl's legacy to science*, Editorial, *Nature* 25/4/97; 380, 653. This paper is reproduced in Annex A.1.2, page A1-128.

years of life. Evidence from the 1950s confirmed the sensitivity of the foetus in the first few months of pregnancy[117]. There have also been studies of the effects of the fallout from nuclear weapons testing in the UK[118] that have shown increases in cancers during the highest period of bomb-fallout. A number of studies, concentrating on the changes in the incidence/mortality of childhood leukaemia immediately following the Chernobyl accident have refined knowledge further, and sparked a debate in relation the impacts of low-level radiation:

- A German study[119] published in 1992 showed that neonatal mortality in Germany had not increased following Chernobyl, but the constant decrease measured over the preceding years had slowed.
- A study from Belarus[120] published in 1993 reported no increase in leukaemia following the Chernobyl.
- A study from Finland[121] published in 1994 showed no excess of leukaemia following Chernobyl that was statistically significant (more than 8 cases per million).
- A review published in 1996 by the European Childhood Leukaemia/Lymphoma Incidence Study[122] found no unexpected excess of leukaemia in Europe that correlated with the levels of fallout from Chernobyl. It concluded that risk estimates for childhood leukaemia were therefore correct.
- A study from Greece[123] published in 1997 reported an increase in childhood leukaemia of 2.6 times amongst the in utero cohort during the period of radioactive fallout.
- A study from the USA[124] published in 1997 indicated a 2-fold rise in childhood leukaemia amongst the in utero cohort. The report also considered the lack of significant findings in Scandinavia, and suggested that this was due to the statistical basis of the study and the different population sizes.
- A study published in 1998 of cancers in Wales and Scotland[125], reviewed and republished[126] in 2000, showed significant increases in infant leukaemia, and also low birth

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[117] A survey of childhood malignancies, Stewart et. al, British Medical Journal 1958; 1, 1495-1508.

[118] *Childhood leukaemia in Great Britain and fallout from nuclear weapons testing*, Haynes and Bentham, *Journal of Radiological Protection* 1995; 15/1, 37-43.

[119] *Neonatal mortality in Germany since the Chernobyl explosion*, Jens Scheer, *British Medical Journal* 28/3/92; 304, 843. This paper is reproduced in Annex A.1.2, page A1-183.

[120] *Child leukaemia after Chernobyl*, *Ivanov* et. al., Nature 21/10/93, 365, 702. This paper is reproduced in Annex A.1.2, page A1-177.

[121] *Fallout from Chernobyl and incidence of childhood leukaemia in Finland, 1976-1992*, Auvinen et. al., *British Medical Journal* 16/7/94; 309, 151-162.

[122] *Childhood leukaemia in Europe after Chernobyl: 5 year follow-up*, Parkin et. al, *British Journal of Cancer* 1996; 73. 1006-1012.

[123] *Infant leukaemia after in utero exposure to radiation from Chernobyl*, Petridou et. al., *Nature* 25/7/97; 382, 352-353. This paper is reproduced in Annex A.1.2, page A1-126.

[124] *Childhood leukaemia in US may have risen due to fallout from Chernobyl*, Joseph Mangano, *British Medical Journal* 19/4/97; 314, 1200. This paper is reproduced in Annex A.1.2, page A1-119.

[125] *Increases in leukaemia in Infants in Wales and Scotland following Chernobyl: Evidence for Errors in Statutory Risk Estimates*, Busby et. al., Green Audit Occasional Papers No 98/2; June 1998.

[126] *Increases in leukaemia in infants in Wales and Scotland following Chernobyl: evidence for errors in statutory risk estimates*, Busby et. al., *Energy and Environment* 2000; 11/2, 127-139

weight in the in utero cohort. It is suggested that the results of this study, combined with other studies, suggest that radiation risks have been underestimated by 100 times or more.

In conclusion, the variability in the results of the post-Chernobyl studies can be explained by many factors – from the selection of geographical areas, to the size of populations and the quality of medical diagnosis. But the post-Chernobyl studies, when combined with other data on the risks of low level radiation, provide an argument that there exists a mechanism whereby ill health may be induced at lower dose rates than the current risks estimates project.

The Agency must have regard to this recent evidence as it begins to quantify the level of error within the current dose risks estimates set by NRPB/ICRP.

5.6. Mechanisms for considering scientific uncertainty as part of the determination of these applications

In response to these challenges to the orthodox position of the acceptability of low doses of radiation, the Environment Agency must impartially assess this new evidence to see if it has a bearing on it's regulatory functions. Whilst NRPB may represent the government body charged with advising on matters of radiological protection, the NRPB's advice cannot remove the obligations put upon the Agency under their statutory obligations to have regard to the best scientific evidence.

The Agency must, in accordance with its statutory guidelines, protect and enhance the environment as a whole, ensuring that it's activities assist the attainment of sustainable development[127]. In doing so, the Agency must be open about its reasoning, and explain the basis of its decision in terms of scientific principles. This same responsibility is also outlined in the of the Government's Chief Scientific Advisor's guideline set out in March 1997[128]:

> *12. In line with the Government's Code of Practice on Access to Government Information, there should be a presumption towards openness in explaining the interpretation of scientific advice. Departments should aim to publish all the scientific evidence and analysis underlying policy decisions on the sensitive issues covered by these guidelines and show how the analysis has been taken into account in policy formulation. Scientists should be encouraged to publish their own associated research findings.*

These guidelines were enlarged in order to assist implementation in July 1998[129], concentrating especially on Government departments, but it did not change the overall basis of the guidance.

The government has also published various reports on environmental risk assessment that the

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[127] Paraphrasing the Agency's principal aims, set out in *The Environment Agency and Sustainable Development*. See Annex A2.4, page A2-29.

[128] *The Use of Scientific Advice in Policy Making – A Note by the Chief Scientific Adviser*, Sir Robert May, Office of Science and Technology, Department of Trade and Industry. March 1997

[129] *The Use of Scientific Advice in Policy Making: Implementation of the Guidelines*, Office of Science and Technology, Department of Trade and Industry, July 1998

Agency must have regard to in making decisions upon this issue[130] [131]. In particular, the Agency need to have regard to the use of the precautionary principle in this case given that:

- Radionuclides, once release, cannot be effectively cleaned from the environment, and therefore once a commitment to discharge is made it cannot be 'recalled' if the health risks are shown to be excessive; and
- One of the potential health impacts identified in recent studies are mutation affecting the germline – and which transmitted to future generations well beyond the period of exposure to radiation.

In terms of what levels of radiation are 'safe', the Agency must assess the available evidence and define its position on the basis of the open and transparent evaluation of the scientific uncertainties involved. Having carried out this exercise, it must then provide sound arguments as to why, or why not, the precautionary principle should be applied in determining these applications. Essentially, it comes down to an argument regarding the level of magnitude of the errors involved in current risk estimates:

- Stather's 1988 report for NRPB[132] indicated that for the Seascale cluster to be radiation induced then Sellafield discharges would have to be a factor of 300 higher than known levels (note that since this report was published that has been evidence that Sellafield's discharges were underestimated over this period);
- Doll's 1999 review of the Seascale cluster[133] indicates that dose levels were 200 times too small to account for illnesses;
- Busby's 2000 follow-up study[134] of leukaemia in areas affected by Chernobyl indicated levels are at least a factor of 100 or more too high;
- Wright's work on α particles and genomic instability[135] would indicate that serious risks exist at the lowest possible dose levels – one α particle interacting with a cell.

Whilst these differences vary, it is also important to realise that there are potentially different mechanisms at work. The studies of low-LET radiation find one level of result, whilst the studies of higher-LET radiation, principally α particles, find not only different levels of effect, but different mechanisms of damage and damage propagation. As well as humans, there is also the consideration of the impacts of radiation on the natural environment. As noted in section 4.1 earlier, studies suggest current levels for wildlife are three orders of magnitude too high.

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[130] *A Guide to Risk Assessment and Risk Management for Environmental Protection*, Department of the Environment, June 1995. Relevant extracts are provided in Annex A2.7, page A2-45.

[131] *Guidelines for Environmental Risk Assessment and Management*, DETR July 2000. Relevant extracts are provided in Annex A2.8, page A2-50.

[132] The risk of childhood leukaemia near nuclear establishments, J.W. Stather et. al., NRPB Report R215, January 1988. Extracts from this report are provided in Annex A1.2, page A1-200.

[133] *The Seascale cluster: a probable explanation*, Richard Doll, *British Journal of Cancer* 1999: 81/1, 3-5. This paper is reproduced in Annex A1.2, page A1-65.

[134] *Excess of other cancers in Wales*, Chris Busby, British Medical Journal 22/1/94; 308: 268. This paper is reproduced in Annex A1.2, page A1-176.

[135] *Radiation Roulette*, Rob Edwards, *New Scientist* 11/10/97. This paper is reproduced in Annex A1.2, page A1-97.

In conclusion, the Environment Agency must resolve the issues regarding the impacts of low-level radiation before proceeding to determine these applications. The Agency must impartially assess this new evidence to see if it has a bearing on it's regulatory functions, and make the results of those deliberations available to the public.

The Agency must resolve:

- **Whether the current risk estimates upheld by NRPB/ICRP are wholly correct, or whether there is uncertainty about their precision – particular in the light of the reassessment of Japanese bomb-survivor data;**
- **Whether the current methodology behind NRPB's/ICRP's risk estimates recognise the varied nature of the biological mechanisms involved in radiation exposure – in particular evidence relating to the bystander effect, genomic instability and the second event theory;**
- **Whether the variability in epidemiological studies on the effects of low level radiation are due to random or systematic errors in the source data on which they are based, or whether there is a likelihood that there are underlying trends which cannot be resolved due to the statistical limitations of the methodology involved; and**
- **Whether there is sufficient evidence to support the assumption that the regulation of discharged to protect humans will protect wildlife, or whether there is sufficient evidence to believe that current ecological risks estimates are inaccurate.**

Whilst NRPB may be the government body charged with advising on matters of radiological protection, the NRPB's advice cannot remove the obligations put upon the Agency under their statutory obligations to have regard to the best scientific evidence. Also, whilst the Agency may adopt a 'wait and see' position in relation to these applications, the release of radioactivity is one instance where a precautionary approach is essential.

There is no viable clean-up or remediation measure for radioactive contamination on the scale produced by the Magnox reactors and B205 at Sellafield. Therefore, in terms of the precautionary principle, the Agency do not require complete proof that current dose risk figures are incorrect before acting to achieve lower discharge levels. In terms of how big a cut the Agency should enact, that again should be a precautionary figure based upon the varying estimates of error within the current figures. In our view, the Agency should seek to cut emissions by a factor of 150 to 250 times.

If the Agency proceed in determining these applications without clarifying the validity of the risk factors on which the Agency's judgement is based then those opposed to the granting of these applications may seek a review of the Agency's decision.

6. Site Specific Issues

This section deals with site-specific objections. Whilst the previous sections have looked at more generic issues – the majority of which apply to most or all of the sites that are the subject of this consultation, the following sections consider each of the sites in turn.

6.1. Berkeley Power Station

Berkeley is now in an advanced stage of decommissioning. The main concern is therefore the minimisation of the transfer of radionuclide from the site to the environment, and the safe management of the radioactive wastes arising as part of decommissioning.

Part 18 of the BNFL documentation pack outlines the proposals for future decommissioning. In our view this is not a complete nor acceptable justification for the continued discharges from this site. There are two particular issues:

- Firstly, there is no detailed reference to best practicable means, in particular what levels of discharge could be achieve for a given level investment. Unless such information is forthcoming, there is no way of knowing if the proposals currently outline represent BPM given the range of alternative treatment or management options that exist. For example improved treatment of liquid effluents to reduce the levels of problematic radionuclides, such as α emitters, to near-zero levels.
- Secondly, whilst Part 19 of the BNFL documentation pack rules out the incineration of contaminated graphite, there appears to be no other solution provided. As outlined in section 3.8 of this report, there are immediate problems disposing of the ^{14}C contaminated graphite from this and other sites. A clear strategy is needed for graphite disposal because of the potential impact that ^{14}C can have on radiation doses to the environment.

In terms of the draft authorisation:

- We regard ‘requirement 2’ of the table of improvements as inadequate. As noted in section 3.5 of this report, the management of waste needs to be handled more strategically, and with more regard to the concepts contained in the waste hierarchy. Therefore we request that within 1 year BNFL must submit a plan, developed on a section-by-section basis across the site, for the management of waste, in particular liquid effluents. This plan should be reviewed annually.
- In our view, ‘requirement 3’ is insufficient, given that during this time BNFL are likely to seek the free-release of materials for reclamation/recovery. Before the release of materials for recycling can commence, there should be a proven method to prevent any contaminated materials leaving the site. Therefore, we request that ‘requirement 3’ is amended to require, in addition to a general characterisation scheme, a scheme to guarantee the quality of free-release materials. Both these schemes should be submitted within 6 months. If this is not acceptable then the movement of free-release material for reclamation off-site should be prohibited until such time as a scheme is in place to guarantee the quality of that material.

- With regard to 'requirement 7', the study of waste generation as part of decommissioning should include a sliding-scale for the completion of the decommissioning programme. This is in the light of the recent information on the position of the Nuclear installations Inspectorate on the period of time BNFL are proposing to decay-store the hulks of the reactors (see Annex A3.8, page A3-38).

We request that the Environment Agency has regard to the above five requests, and addresses these issues in its decision document.

6.2. Bradwell Power Station

In our view, it is questionable whether Bradwell should be allowed to operate to the proposed closure date in March 2002. This is because of the failure to justify the level of power generation (at 246MWe, the smallest of all the Magnox reactors seeking authorisation) for the level of radioactive discharges produced – see section 3.2 of this report. BNFL have advanced no convincing case for the continued operation of this plant in its current state – for example the breach of the 300μSv source constraint.

Likewise, it is clear that the levels of 'other radionuclides' will increase slightly with the continued operation of the plant. The rounding in the table provided under Question 49 of Part 11 of the BNFL documentation pack obscures a 6% increase in the discharge of 'other nuclides' (the level is increasing from 56.58 to 60GBq/yr). In our view, the Agency should be seeking to reduce discharges in order, over the longer term, to meet Britain's OSPAR commitments.

We object to the continued incineration of waste on site at Bradwell. This process is not monitored sufficiently to ensure that the radioactive and non-radioactive emissions from the incinerator do not cause a threat to health on- or off-site. At the very minimum, the incinerator should meet the emission standards required under the IPC waste incineration standard for combustion gases, heavy metals and VOCs/dioxins.

Finally, in terms of the draft authorisation, we regard 'requirement 2' of the table of improvements as inadequate. As noted in section 3.5 of this report, the management of waste needs to be handled more strategically, and with more regard to the concepts contained in the waste hierarchy. Therefore we request that within 1 year BNFL must submit a plan, developed on a section-by-section basis across the site, for the management of waste, in particular liquid effluents. This plan should be reviewed annually.

We request, as a priority, that the Agency review it's position with regard to the future operation of the Bradwell plant, and demand that BNFL begin its closure forthwith. Failing this, we also request that efforts should be made to reduce the discharge levels of nuclides in the liquid waste stream, and that a comprehensive waste management plan is enacted for the site. Finally, monitoring of the incinerator should be improved to demonstrate compliance with the waste incineration standards under IPC. We request that the Environment Agency has regard to the above requests, and addresses these issues in its decision document.

6.3. Dungeness A Power Station

In our view, it is questionable whether Dungeness should be permitted to generate power. This is because of the failure to justify the level of power generation for the level of radioactive discharges produced – see section 3.2 of this report. BNFL have advanced no convincing case for the continued operation of this plant in its current state – for example the breach of the 300μSv source constraint. The problems with regard to carbon dioxide leaks, ^{14}C releases from the primary circuit, and the management of contamination in the fuel storage ponds, also weigh in favour of closure.

In any case, the continued operation of Dungeness beyond 2003 is not justified because of the implications for Britain meeting its OSPAR obligations for the reduction of radioactive discharges. This is because B205 at Sellafield cannot close until the Magnox reactors have closed and de-fuelled. In our view, Dungeness should not be permitted to operate beyond 2003.

We object to the continued incineration of waste on site. In our view, this process is not monitored sufficiently to ensure that the radioactive and non-radioactive emissions from the incinerator do not cause a threat to health on- or off-site. At the very minimum, the incinerator should meet the emission standards required under the IPC waste incineration standard for combustion gases, heavy metals and VOCs/dioxins.

In terms of the draft authorisation:

- We regard 'requirement 2' of the table of improvements as inadequate. As noted in section 3.5 of this report, the management of waste needs to be handled more strategically, and with more regard to the concepts contained in the waste hierarchy. Therefore, we request that within 1 year BNFL must submit a plan, developed on a section-by-section basis across the site, for the management of waste, in particular liquid effluents. This plan should be reviewed annually.
- We object to the proposed level of the tritium discharge since it is set at a level that reflects BNFL's inability to control tritium releases rather than the standard procedure of setting levels at 1.5 times the annual average discharge. A tight limit must be set in order to ensure the Agency properly enacts the 'polluter pays principle' in accordance with its statutory objectives.

We request, as a priority, that the Agency review its position with regard to the future operation of the Dungeness plant, and demand that BNFL begin its closure forthwith. Failing this, the plant should close by 2003 at the latest. We request that a comprehensive waste management plan is enacted for the site. The discharge level for gaseous tritium is too high, and we request that is lowered to 1.5TBq. Finally, monitoring of the incinerator should be improved to demonstrate compliance with the waste incineration standards under IPC. We request that the Environment Agency has regard to the above requests, and addresses these issues in its decision document.

6.4. Hinkley Point A Power Station

Whilst welcoming BNFL's decision to close Hinkley Point A, we are concerned that the reissued draft authorisation does not adequately address the issues created by the proposed closure of the plant. In our view, BNFL should implement a proper review of the licensing/regulatory needs for the site to enable safe decommissioning and then reapply for authorisation. It is not possible to 'retrofit' the required information at this late stage.

We are also concerned with regard to the problems monitoring ^{14}C discharges from the site. There needs to be a far more detailed description of:

- The historic development of this fault, and the likely impact on discharges over that period; and
- The likelihood that this fault was replicated in other monitoring systems, or whether the fault is present in monitoring systems at other BNFL sites.

Relating to the proposed decommissioning of the plant, two issues arise:

- Firstly, there is no detailed reference to best practicable means, in particular what levels of discharge could be achieve for a given level investment. Unless such information is forthcoming, there is no way of knowing if the proposals currently outline represent BPM given the range of alternative treatment or management options that exist. For example improved treatment of liquid effluents to reduce the levels of problematic radionuclides, such as α emitters, to near-zero levels.
- Secondly, a clear strategy is needed for graphite disposal because of the potential impact that ^{14}C can have on radiation doses to the environment. As outlined in section 3.8 of this report, there are immediate problems disposing of the ^{14}C contaminated graphite from this and other sites.

In terms of the amended draft authorisation:

- We regard 'requirement 2' of the table of improvements as inadequate. As noted in section 3.5 of this report, the management of waste needs to be handled more strategically, and with more regard to the concepts contained in the waste hierarchy. Therefore, we request that within 1 year BNFL must submit a plan, developed on a section-by-section basis across the site, for the management of waste, in particular liquid effluents. This plan should be reviewed annually.
- In our view 'requirement 3' is insufficient, given that during this time BNFL are likely to seek the free-release of materials for reclamation/recovery. Before the release of materials for recycling can commence, there should be a proven method to prevent any contaminated materials leaving the site. Therefore, we request that 'requirement 3' is amended to require, in addition to a general characterisation scheme, a scheme to guarantee the quality of free-release materials. Both these schemes should be submitted within 6 months. If this is not acceptable then the movement of free-release material for reclamation off-site should be prohibited until such time as a scheme is in place to guarantee the quality of that material.
- With regard to 'requirement 8', the study of waste generation as part of decommissioning should include a sliding-scale for the completion of the decommissioning programme. This is

in the light of the recent information on the position of the Nuclear installations Inspectorate on the period of time BNFL are proposing to decay-store the hulks of the reactors (see Annex A3.8, page A3-38).

We request that the Environment Agency has regard to the above five requests, and addresses these issues in its decision document.

6.5. Oldbury Power Station

In our view, the continued operation of Oldbury beyond 2003 is not justified because of the implications for Britain meeting its OSPAR obligations for the reduction of radioactive discharges. This is because B205 at Sellafield cannot close until the Magnox reactors have closed and de-fuelled. BNFL's proposed alternative of 'Magrox' fuel is, in our opinion, unacceptable. There is no evidence that Magrox fuel will be safe in operation, it has not been approved for use by NII, and there is no evidence relating to the effect Magrox fuel will have on plant discharges. In our view, Oldbury should not be permitted to operate beyond 2003.

We object to the continued incineration of waste on site. In our view, this process is not monitored sufficiently to ensure that the radioactive and non-radioactive emissions from the incinerator do not cause a threat to health on- or off-site. At the very minimum, the incinerator should meet the emission standards required under the IPC waste incineration standard for combustion gases, heavy metals and VOCs/dioxins.

We are also concerned by the failure to properly monitor tritium discharges. We request that a fuller account of how this problem arose is provided by BNFL, and that the Agency enact conditions to ensure that similar failure cannot happen again.

In terms of the draft authorisation:

- We regard 'requirement 2' of the table of improvements as inadequate. As noted in section 3.5 of this report, the management of waste needs to be handled more strategically, and with more regard to the concepts contained in the waste hierarchy. Therefore, we request that within 1 year BNFL must submit a plan, developed on a section-by-section basis across the site, for the management of waste, in particular liquid effluents. This plan should be reviewed annually.
- We object to the proposed levels of gaseous ^{14}Ar, ^{35}S and ^{14}C discharges – they are in our view 20% too high. There is no obvious justification from the Agency as to why they are departing from their usual practice of setting limits at 1.5 times the annual average discharge. A tight limit must be set in order to ensure the Agency properly enacts the 'polluter pays principle' in accordance with its statutory objectives.
- We object to the proposed levels of liquid tritium, ^{137}Cs discharges – they are respectively, in our view, two and four times too high. There is no obvious justification advanced by the Agency as to why they are departing from their usual practice of setting limits at 1.5 times the annual average discharge. A tight limit must be set in order to ensure the Agency properly enacts the 'polluter pays principle' in accordance with its statutory objectives.

We request, as a priority, that the Agency review it's position with regard to the future operation of the Oldbury plant beyond 2003, and demand that BNFL begin its plan its closure at that date. Failing this, we request that a comprehensive waste management plan is enacted for the site. The discharge level for gaseous ^{41}Ar, ^{35}S and ^{14}C are too high, and we request that they lowered to 450, 0.3 and 4.25TBq respectively. Likewise, liquid tritium and ^{137}Cs limits should be lowered to 0.5 and 0.2TBq respectively. Procedures must be put in place to ensure that the measurement of radionuclide discharges is properly carried out, and that the errors at Oldbury are not replicated at other sites. Finally, monitoring of the incinerator should be improved to demonstrate compliance with the waste incineration standards under IPC. We request that the Environment Agency has regard to the above requests, and addresses these issues in its decision document.

6.6. Sizewell A Power Station

In our view, Sizewell A should not be permitted to generate power. This is because of the failure to justify the level of power generation for the level of radioactive discharges produced – see section 3.2 of this report. BNFL have advanced no convincing case for the continued operation of this plant in its current state. It produces too little power, and it alone represents 47% of the total discharges it is proposed to permit for all the Magnox reactor sites.

In any case, the continued operation of Sizewell beyond 2003 is not justified because of the implications for Britain meeting its OSPAR obligations for the reduction of radioactive discharges. This is because B205 at Sellafield cannot close until the Magnox reactors have closed and de-fuelled. In our view, Sizewell should not be permitted to operate beyond 2003.

We object to the continued incineration of waste on site. In our view, this process is not monitored sufficiently to ensure that the radioactive and non-radioactive emissions from the incinerator do not cause a threat to health on- or off-site. At the very minimum, the incinerator should meet the emission standards required under the IPC waste incineration standard for combustion gases, heavy metals and VOCs/dioxins.

In terms of the draft authorisation:

- We regard 'requirement 2' of the table of improvements as inadequate. As noted in section 3.5 of this report, the management of waste needs to be handled more strategically, and with more regard to the concepts contained in the waste hierarchy. Therefore, we request that within 1 year BNFL must submit a plan, developed on a section-by-section basis across the site, for the management of waste, in particular liquid effluents. This plan should be reviewed annually.
- We object to the proposed level of the gaseous tritium discharge since it is set at a level that reflects BNFL's inability to control tritium releases rather than the standard procedure of setting levels at 1.5 times the annual average discharge. A tight limit must be set in order to ensure the Agency properly enacts the 'polluter pays principle' in accordance with its statutory objectives.
- We object to the proposed level of the gaseous ^{14}C discharge since it is set at a level that

reflects BNFL's inability to control releases, based as it is on an extrapolation of data assuming the continued deterioration of the reactor core (ref. BNFL documentation pack Part 16, question 3.4). The Agency must set limits based on past performance and then revise down in order to minimise doses, and give effect to 'best practicable means' – otherwise BPM stops still. A tight limit must be set in order to ensure the Agency properly enacts the 'polluter pays principle' in accordance with its statutory objectives.

- We object to the proposed level of the liquid tritium and ^{137}Cs discharges since it is set at a level that reflects BNFL's inability to control releases rather than the standard procedure of setting levels at 1.5 times the annual average discharge. A tight limit must be set in order to ensure the Agency properly enacts the 'polluter pays principle' in accordance with its statutory objectives.

We demand that the Agency review its position and seek the closure of Sizewell A forthwith. Failing this, we request that the Agency review it's position with regard to the future operation of the Sizewell A plant beyond 2003, and demand that BNFL begin its plan its closure at that date. We request that a comprehensive waste management plan is enacted for the site. The discharge level for gaseous tritium is too high, and we request that is lowered to 3TBq. Likewise, liquid tritium and ^{137}Cs limits should be lowered to 9 and 0.2TBq respectively. Finally, monitoring of the incinerator should be improved to demonstrate compliance with the waste incineration standards under IPC. We request that the Environment Agency has regard to the above requests, and addresses these issues in its decision document.

6.7. Trawsfynydd Power Station

Trawsfynydd is now in an advanced stage of decommissioning. The main concern is therefore the minimisation of the transfer of radionuclide from the site to the environment, and the safe management of the radioactive wastes arising as part of decommissioning. However, the situation is complicated at Trawsfynydd because the need to discharge into an inshore lake has left a level of contamination proportionately higher than other Magnox sites. There is also a problem resulting from the significant contamination levels in the lake which need to be remediated.

Part 6 of the BNFL documentation pack outlines the proposals for future decommissioning. In our view this is not a complete nor acceptable justification for the continued discharges from this site. There are three particular issues:

- Firstly, there is no detailed reference to best practicable means, in particular what levels of discharge could be achieve for a given level investment. Unless such information is forthcoming, there is no way of knowing if the proposals currently outline represent BPM given the range of alternative treatment or management options that exist. For example improved treatment of liquid effluents to reduce the levels of problematic radionuclides, such as α emitters, to near-zero levels.

- Secondly, the plan for decommissioning must include detailed proposals for the remediation of Llyn Trawsfynydd. In our view, the levels of contamination represent a risk to health through the resuspension of silts containing a variety of radionuclides. The management of water levels in the lake to prevent resuspension by the wind is not, in our view, a suitable or

sustainable long-term solution. Therefore, BNFL should begin a remediation program to reduce the radioactivity levels in the silts of the lake. As part of this process, BNFL should conduct studies examining the bioaccumulation of radionuclides in aquatic plants and organisms to determine the priority areas for reducing contamination levels.

- Thirdly, a clear strategy is needed for graphite disposal because of the potential impact that ^{14}C can have on radiation doses to the environment. As outlined in section 3.8 of this report, there are immediate problems disposing of the ^{14}C contaminated graphite from this and other sites.

In terms of the draft authorisation:

- We regard 'requirement 2' of the table of improvements as inadequate. As noted in section 3.5 of this report, the management of waste needs to be handled more strategically, and with more regard to the concepts contained in the waste hierarchy. Therefore, we request that within 1 year BNFL must submit a plan, developed on a section-by-section basis across the site, for the management of waste, in particular liquid effluents. This plan should be reviewed annually.
- In our view 'requirement 3' is insufficient, given that during this time BNFL are likely to seek the free-release of materials for reclamation/recovery. Before the release of materials for recycling can commence, there should be a proven method to prevent any contaminated materials leaving the site. Therefore, we request that 'requirement 3' is amended to require, in addition to a general characterisation scheme, a scheme to guarantee the quality of free-release materials. Both these schemes should be submitted within 6 months. If this is not acceptable then the movement of free-release material for reclamation off-site should be prohibited until such time as a scheme is in place to guarantee the quality of that material.
- With regard to 'requirement 7', the study of waste generation as part of decommissioning should include a sliding-scale for the completion of the decommissioning programme. This is in the light of the recent information on the position of the Nuclear Installations Inspectorate on the period of time BNFL are proposing to decay-store the hulks of the reactors (see Annex A3.8, page A3-38).
- We object to the proposed level of the gaseous ^{14}C discharge since it is based not upon routine discharges, but non-routine work on the reactor – increasing discharges by 8-fold. BNFL should demonstrate a better system to control ^{14}C levels through better management of the decommissioning operations rather than setting a limit 5 times what it should be for routine discharges. The Agency must set limits based on past performance and then revise down in order to minimise doses, and give effect to 'best practicable means' – otherwise BPM stops still. A tight limit must be set in order to ensure the Agency properly enacts the 'polluter pays principle' in accordance with its statutory objectives.
- We object to the proposed level of the gaseous 'other nuclides, liquid tritium liquid ^{137}Cs and liquid ^{90}Sr discharges since it is set at a level that reflects BNFL's inability to control releases, in the same manner as the ^{14}C gaseous discharge, rather than the standard procedure of setting levels at 1.5 times the annual average discharge. A tight limit must be set in order to ensure the Agency properly enacts the 'polluter pays principle' in accordance with its statutory objectives.

We request that the Environment Agency review their position with regard to the proposed limits and conditions of the draft authorisation. The levels of gaseous ^{14}C, tritium and 'other nuclides' should be reduced to 6.5GBq, 0.6TBq and 10MBq respectively. The levels of liquid tritium, ^{137}Cs and ^{90}Sr should be reduced to 0.35TBq, 15GBq and 30GBq respectively. A scheme must be put in place for the monitoring and remediation of radiation levels in Llyn Trawsfynydd. Likewise, there needs to be greater emphasis on utilising the best technologies to minimise liquid discharges from the site, and in finding an acceptable disposal solution for graphite. We request that the Agency address these issues in its decision document.

6.8. Wylfa Power Station

In our view, the continued operation of Wylfa beyond 2003 is not justified because of the implications for Britain meeting its OSPAR obligations for the reduction of radioactive discharges. This is because B205 at Sellafield cannot close until the Magnox reactors have closed and de-fuelled. BNFL's proposed alternative of 'Magrox' fuel is, in our opinion, unacceptable. There is no evidence that Magrox fuel will be safe in operation, it has not been approved for use by NII, and there is no evidence relating to the effect Magrox fuel will have on plant discharges. In our view, Wylfa should not be permitted to operate beyond 2003.

We object to the continued incineration of waste on site. In our view, this process is not monitored sufficiently to ensure that the radioactive and non-radioactive emissions from the incinerator do not cause a threat to health on- or off-site. At the very minimum, the incinerator should meet the emission standards required under the IPC waste incineration standard for combustion gases, heavy metals and VOCs/dioxins.

In terms of the draft authorisation:

- We regard 'requirement 2' of the table of improvements as inadequate. As noted in section 3.5 of this report, the management of waste needs to be handled more strategically, and with more regard to the concepts contained in the waste hierarchy. Therefore, we request that within 1 year BNFL must submit a plan, developed on a section-by-section basis across the site, for the management of waste, in particular liquid effluents. This plan should be reviewed annually.
- We object to the proposed levels of beta particulate discharges – they are in our view 250% too high. There is no obvious justification advanced by the Agency as to why they are departing from their usual practice of setting limits at 1.5 times the annual average discharge. A tight limit must be set in order to ensure the Agency properly enacts the 'polluter pays principle' in accordance with its statutory objectives.

We request, as a priority, that the Agency review it's position with regard to the future operation of the Wylfa plant beyond 2003, and demand that BNFL begin its plan its closure at that date. Failing this, we request that a comprehensive waste management plan is enacted for the site. The discharge level for beta particulates are too high, and we request that they lowered to 0. 4GBq. Finally, monitoring of the incinerator should be improved to demonstrate compliance with the waste incineration standards under IPC. We request that the Environment Agency has regard to the above, and addresses these issues in its decision document.

6.9. Berkeley Centre

With regard to Berkeley centre, in our view there is insufficient data on past release trends to reliably set discharge rates. No historic trends are shown in the BNFL documentation for emissions. Part 14 of the BNFL documentation pack, question 16, gives some figures but very little to substantiate anything except beta particulate. For example, only 1 tritium result for 1 month, and 8 months of ^{14}C data, over a 6½ year period.

In our view, there is insufficient data to set discharge limits for Berkeley centre in a manner that:

- **Can be validated to ensure proper justification of the discharges; and**
- **Ensure that best practical means is applied through the progressive control and lowering of discharge levels.**

BNFL should be instructed to submit new evidence relating to the past, and likely future emissions from Berkeley Centre given the research work it is proposed to undertake. In recognition of the difficulties involved in this process, it may be more realistic to manage releases on a building-by-building basis. This would also give greater scope for improvement in future discharge levels through the management of discharges near the source, rather than at the site level.

7. Conclusions and Recommendations

Note – to aid the referencing of the recommendations, the numbers in square brackets indicate the section of the report that the item is detailed in.

The purpose of this report, in terms of the aims of its author and those commissioning the work, is to review the applications by BNFL for RSA authorisations to permit operation of the Magnox power station and research sites. Our position is that these applications must be determined in accordance to the public interest, having regard to the most recent evidence on the safety of these plants, and the damage that may result from their radioactive and non-radioactive discharges.

The opportunity to comment on the applications for the Magnox sites is welcome. While we welcome the efforts to provide comprehensive documentation, the format of the reports, and the large amount of duplication between sites, raise issues about the 'readability' of the consultation documents for the general public. Likewise, the use of the latest software will always cause problems. But these problems aside, we hope that the Agency can work on resolving these difficulties in the future. [2.1]

In terms of the applications themselves, the documentation for most of the sites was suitable for the purpose. However, at points there was a need for more clarity of the data being presented (caused in part by the lack of data in relation to some aspects of the applications).

In terms of the content of the applications, and the Agency's position on them [6.1 to 6.9]:

- The applications for Berkeley Power Station and Trawsfynydd needed far more detail with regards to the justification for future decommissioning operations in order to demonstrate 'best practicable means'.
- The application for Hinkley Point A is, in our view, in need of total review because of the decision to close the plant. It is not possible to 'retrofit' the required standard of data at such a late stage in the process.
- There is a general failure to consider the need to close the plants, either because of their clear inefficiency at generating nuclear energy, or because of the need to meet Britain's obligations under the OSPAR convention. Meeting OSPAR will require the closure of B205 at Sellafield by 2015, but before this can happen the Magnox stations will have to close down by 2003 or 2004 at the latest.
- Little consideration is given to the non-radioactive pollutants emitted from incineration, and these needs to be far stricter control of these plants to IPC emission standards.
- In general, various changes are needed to the draft authorisations to implement lower discharge standards, or to require better waste management in order to achieve lower discharge levels in the future.

After considering the information in the Agency's consultation documents, and the copies of BNFL's documentation, it is our view that the following actions should be taken by the Agency:

Legal and procedural issues

In terms of the case presented in the consultation documents, have not properly outlined or

discharged their legal obligations in relation to the 'attainment of the objective of sustainable development'. In particular [2.2]:

- In the consultation reports the Agency effectively ducks the issue of taking the decisions on these applications in accordance with the tests and principles outlines in the UK Sustainable Development Strategy, and the Agency's own statutory guidelines.
- The Agency can no longer make valid decisions relying on the policies contained in Cm2919. That document has been overtaken by events both in relation to radioactive discharges, and radioactive waste management.
- In terms of both the 1995 and the recent risk assessment guidelines, and the Agency's statutory guidelines, the Agency must evaluate any evidence that current practices may give rise to unforeseen or unintended harm. Then, having evaluated the evidence, they must justify either taking positive action to restrict potential harm, or be able to justify not taking positive action.
- At no point in the consultation documents have the Agency, or BNFL, discussed the large uncertainties that exist in relation to the environmental impacts of radioactive discharges. Likewise, there has been no objective quantification of the capacity of the environment to accept discharges without unacceptable levels of harm.
- In terms of regulating radioactive wastes, there are few other such issues where the Agency must be obliged to consider, in relations to all aspects of these applications, to apply the precautionary principle. But the Agency's reliance on numerical limits, and on defeated or untested assumptions within dated government policy documents, they have precluded the kinds of assessment that are necessary to test if precautionary action is required.
- All-in-all, given the various issues raised in relation to the attainment of sustainable development, it is our view that the Agency have not properly interpreted or discharged their legal and policy obligations in relation to sustainable development.

The Agency must take steps to remedy these deficiencies in the consultation documents, and their consideration of policy documents, before proceeding further in determining these applications.

It is our view that the justification provided by BNFL, and amplified by the Agency in their consultation document, does not fully meet the objectives specified in the *Basic Safety Standards Directive* in terms of the justification of practice [2.3]. Whilst the justification for decommissioning can be made within its own right, since their is no comparable operation in the non-nuclear sector, the justification for power generation fails to make comparisons with other options for power generation available in society. As well as testing the justification within the power generation sector, justification also needs to be made within the nuclear generation sector. This must be done to ensure efficiency, but no such comparisons are made. In our view, on the basis of the failure to justify the operation of the generating plants within the context of the whole energy generation sector, the Agency cannot determine these applications as they are procedurally incomplete.

The Environment Agency's approach to the consideration of risk must be more engaging of public opinion than the pessimistic approach of the HSE's *Tolerability of Risk* (TOR) reports [2.4]. The Agency's views of public perception, based as they are on the TOR reports, are dated, and incompatible with recent decisions of the High Court. It is clear that the Agency must:

- Seek to re-evaluate the public acceptability of nuclear power since the assumptions that underpin the TOR reports are no longer valid;
- Make a clear statement on how the Agency, in recognition of recent case law, will modify their procedures on the assessment of public concerns about nuclear power; and, as a result of this
- Begin a process to identify the various different public concerns about the Magnox programme and seek to incorporate those concerns within the Agency's final determination of these applications.

Case laws on public perception give the public the right to have their 'fears' on nuclear power diligently investigated by the Environment Agency. The Environment Agency are required to determine an authorisation for pollution that has uncertain and poorly characterised effects. There is genuine public concern about adverse health effects from radioactive discharges, backed up by significant evidence to validate those concerns. The Environment Agency must therefore give strong weight to the opinions expressed by the public in terms of health effects, and act to restrict the terms of, or even refuse these applications in order to address the substance of these objections.

In determining these applications the Agency must be able to show, both through the writing of their decision document, and if challenged in court, that they had regard to the European convention on Human Rights [2.5]. In particular, the Agency must demonstrate that it has had regard to all the objections submitted to it, and that these objections have been fairly and objectively investigated.

Finally, in terms of procedure, we request that the Agency consider another round of public consultation follow their evaluation/investigation of the objections raised in this and other responses. Note also, if the Agency wish, we would be willing to meet and discuss the objections made in this report. [2.6]

Engineering and economics

The Environment Agency must direct BNFL to incorporate values for external costs and benefits [3.1]. Whilst such values can be credited to the balance sheet for nuclear generation, we must also debit other costs. Unless BNFL's justification incorporates externalities it cannot the terms of the *Basic Safety Standards Directive*.

As part of the economic case for the operation of the Magnox plants, the potential for economic difficulties at BNFL [3.1], because of the current problems relating to the loss of contracts after their recent safety breaches, must also be investigated before these applications are determined.

From an analysis of the data provided by the Agency and BNFL, it is clear that there is a large disparity in the operating efficiencies, in terms of power generation levels incurring certain levels of radioactive discharge, that must be considered when evaluating 'justification of practice' [3.2]. In our view:

- Sizewell A, Bradwell and Dungeness A should not be permitted to operate for power generation – the level of radioactive discharges cannot be justified by the quantities of energy production;

- Given the need to close Building B205 at Sellafield in order to meet the requirement for '*substantial reductions by 2000*', the Agency should set a date for closing the Magnox stations within the next two or three years (2003 at the latest), in order that the complete closure of B205 can be brought forward well before the 2015 (five years early because of the time lag for discharge reductions). This is to allow 10 years for the reprocessing or other treatment of the substantial quantity of spent fuel that will arise due to the near simultaneous closure of all the Magnox stations.

The economic assessment that forms the heart of BNFL's justification case, and relying heavily as it does on discounted costs, is unrealistic because it does not factor-in the potential regulatory risks [3.3]. In particular the imposition of higher standards, and the potential requirement at the governmental level for the early closure of B205 at Sellafield, and hence the premature closure of the Magnox stations. The Agency must direct BNFL to reassess the economic case, factoring in various scenarios of regulatory change.

In terms of Britain's obligations in meeting the OSPAR convention, and the requirements for the reduction of radioactive to 'near background' levels, it is within the discretion of the Environment Agency to seek large cuts in the discharges from the Magnox plants [3.4]. The Agency must not wait until the Government has finally made its policy in relation to implementing OSPAR. The delay caused by that delay, and then the period taken to review the authorisations again, could delay the whole process so long that the 2020 target date could be missed. As part of this process, the Agency must also consider the option of seeking the closure of all Magnox plants by a set date. This is in order to facilitate the processing/treatment of spent fuel at a rate that will allow B205 to completely close by the year 2015. In order to avoid slippage an earlier date would be preferable.

Operating collaterally with the need to close plants to facilitate the closure of B205 at Sellafield, the Agency must require, by condition, an overall management plan for the production and treatment of radioactive liquid effluents on the site [3.5]. Such a plan is the first stage of planning the reduction and elimination of liquid effluent discharges to the environment. It should be implemented within a specified timescale as a condition of the authorisation. The principles of the waste hierarchy must be applied to liquid wastes in order to minimise the production of effluent that requires treatment.

For those sites that are in/entering the decommissioning phase, an effluent management plan is extremely important [3.5]. Decommissioning, whilst leading to large decreases in atmospheric emission, can lead to increases in the discharge of some nuclides to sea. Therefore, BNFL should be required, within six months of the granting of the authorisation, to implement a system of developing new infrastructure, management and controls to ensure that the discharges from decommissioned sites achieve regular targeted reductions in the discharge of certain nuclides. Emphasis should be placed on those nuclides that have a tendency to bioaccumulate, those that are alpha-emitting nuclides, and nuclides that decay to alpha emitters within a few years of discharge.

In our view, spent nuclear fuel is a 'waste' material. As such, it requires authorisation for transfer away from the Magnox reactor sites to Sellafield [3.6]. The Environment Agency must perform the necessary updating of the authorisations to include this material within the terms of the draft authorisations. We then we suggest that the new drafts are reissued for consultation as this would represent a substantial variation at each site.

In terms of BNFL's proposals to change to Magrox fuel at Wylfa and Oldbury, there are legal

arguments for why the proposed change in fuel should be subject to an environmental statement [3.7]. The Environment Agency must request an environmental impact statement detailing the potential changes to radioactive discharges as a result of the change in fuel. If this is not forthcoming then the Agency must not rely in any way on the introduction of Magrox fuel at a future date when determining these applications.

Finally, there are a number of issues relating to the longer-term decommissioning issues at the three closed sites, and also the other five sites at such time as BNFL decide to close them [3.8]:

- We request that, for the time being, the Agency refrain for giving permission for the 'free release' of materials produced from decommissioning operations. If the Agency does not do this, then we demand that procedures and monitoring systems to monitor this material are introduced immediately. These must ensure that the material that is released for recycling will have an extremely low probability of containing any material above free release limits.
- We request that the Agency give an account as to why the levels set for decommissioning at the various non-operation sites vary to such an extent. The Agency must explain how this can happen if BPM is being evenly at all sites, and what will be done to ensure that all sites, including reactors to be close in the future, meet similar low discharge levels.
- The Agency must have regard to the problems of Carbon-14 (^{14}C) disposal, and the potential impacts if this material is incinerated during the process of decommissioning. In particular, BNFL should identify options and contingencies, together with their relative environment impacts, for how the hundreds of tonnes of graphite arising during decommissioning work will be dealt with.

It is important that all these issues must be addressed as part of the Agency's determination process.

Environmental impacts

There is a legal argument that the discharge of radioactivity from the Magnox sites will breach the Habitats directive, both in terms of the potentially lethal effects on protected species, and in the degradation of their habitats [4.1]. There is a growing body of evidence that the damaging and lethal effects of radiation on wildlife can be demonstrated at levels far below those suggested as 'acceptable' by ICRP and others. The position of ICRP, that the protection of humans will ensure the protection of wildlife can be shown to be outdated – and is being criticised by other policy makers and commentators.

The acceptance that certain members of certain species will be killed as a result of the discharges from the Magnox plants means that the discharges could be unlawful. If the species concerned were protected, the discharges that resulted in that death would be unlawful if it could not be proven the discharges were unavoidable. The sub-lethal effects of discharges that lead to illness or loss of general/reproductive fitness, resulting from the deterioration of the environment, are also a relevant consideration in terms of Article 12(d) of the Directive and must be assessed by the Agency. It is up to the Agency and BNFL to prove that the discharges from the Magnox plants will not cause damage or death to protected species, or that if such effects do occur that these impacts could not reasonably be avoided.

The modelling of exposures from the emissions of radioactive materials from the Magnox reactors is overly simplistic [4.2]. The use of older 'standard' models has been a matter of convenience, not an exercise in producing a meaningful quantification of the effects of the releases from these sites. The use of an R-91/R-157 derived model is completely inadequate for the modelling of emissions from these sites. Likewise, the method of it's use is open to criticism. The modelling of emissions needs to be completely reviewed and reassessed, using a modelling protocol that is scientifically sound for the emissions and dispersion being studied, and which is acceptable to the public.

The Agency must also require toxicological impact studies of the radionuclides release from the Magnox plants [4.2]. Unless there is an exercise to determine the significance of the chemical, as opposed to the radiological effect of discharges, the risk of the site will not be adequately assessed. In terms of the HSE's *Tolerability of Risk* report, and other reports (such as those cited earlier), it would not be valid to exclude one facet of risk from the assessment of this site. The ordinary chemical toxicity of radioactive compounds, and the radiological risk, are inseparable in a process that authorises the release of those compounds.

The potential for radioactive decay to give rise to more, or more hazardous radionuclides should be taken account of by the Environment Agency when setting discharge limits [4.3]. Rather than setting limits on a general numerical basis, the limits should be based on a risk assessment considering:

- The likelihood of radioactive decay producing more hazardous radioactive emissions;
- The potential for the creation of radionuclides whose chemical form has a high bioavailability to living organisms; and
- The potential for the decay of longer-lived radionuclides to produce short-lived radionuclides, thereby increasing the likelihood of tissue damage should those radionuclides be taken-up in living organisms.

At the same time steps should be taken to discover and if possible control the chemical form of the discharges to ensure that they as a low bioavailability and environmental mobility [4.3]. If necessary, the Agency should required the installation of treatment plants in order to modify or control the most undesirable releases of radionuclides, in particular tritium.

Finally, the Agency, in assessing doses from future discharges and in setting levels to control doses, must have regard to the impact of the historic legacy of radionuclides in the local environment [4.3]. Where there is an excess of certain nuclides in the environment with the potential to increase radiation doses then the future discharge of that radionuclide must be reduced.

Radiation and health impacts

Observed incidence of certain cancers surrounding nuclear establishments cannot be explained by current risk models [5.2]. Whilst they is always a possibility of an unknown cause, the failure of the radiological protection establishment in the UK and elsewhere to re-evaluate and justify their own models in the face of mounting evidence confirms the unreliability of these models. With regard to the population-mixing explanation for these observed health effects, this theory can only be given credence provided that at no point are the data on which conventional dose–response model are based are proven incorrect. Our position is that there is sufficient evidence to question the basis of current dose–response models, and therefore the 'importance' of the population-mixing hypothesis

decreases.

Studies of genetic variability demonstrate that the population cannot, in its entirety, be treated as homogeneous [5.2]. The effects of homogeneity of risk models, and in the excess of illness that can be assumed to arise from radioactive discharges, must be considered within the Agency's risk estimates when determining these applications. Work by Stewart and Kneale on the Japanese bomb-survivor datasets demonstrates the shortcomings in the datasets on which the official risk models are based. The only other significant source of exposure data – radiation workers in the nuclear industry – also contains systematic errors due to dosimetry practices that may not give a representative set of data on the impacts of low-level radiation exposure. The use of this data to supplement the bomb-survivor datasets is unlikely to provide a qualitative improvement to the risk estimates for populations exposed to low-level radiation. The implications of the research on the systematic errors in both bomb-survivor and nuclear industry worker datasets must be clarified in order that the Agency can validate it's own dose assessment procedures which are based on these datasets.

The basis on which doses are assessed as part of regulatory processes are open to question. New evidence suggests that both the biological mechanisms involved in cell irradiation, and the qualitative impacts of different types of radiation, are not properly quantified within the current dose equivalence methodology [5.3]. The current methodologies also mean that some radionuclides that are currently considered as a low hazard may actually be far more prominent in terms of the initiation or development of cancer. The Environment Agency must demonstrate, given the recent evidence to the contrary, that current equivalent dose methodologies are suitable for use in order to evaluate health impacts.

Other recent scientific research suggest that there may be other processes taking place than those assumed by orthodox dose models when radiation impacts a cell [5.4]. In particular, that the effects of irradiation may initiate a sequence of biochemical changes that result not only in cancer but other illnesses. These findings cast serious doubt on the efficacy of current radiation risk models. The Environment Agency must investigate,

- the implications of research into the bystander effect for the traditional radiation risk models, and the likelihood that such processes could lead to health impacts at dose levels many times smaller than those currently suggested; and
- the implications of genomic instability, not only in terms of the malignant but also the non-malignant health effects, on the current regulatory systems for nuclear plants;

...before proceeding to determine these applications. The Agency must prove that this new research has no bearing on their role as a regulator of radioactive discharges to the environment. If not, then the Agency must act in a precautionary manner and restrict discharges to levels where the risks are two orders of magnitude below current risk estimates (this being the likely level of error – see section 5.6 below).

The impacts of the Chernobyl accidents have contributed valuable new data to the debate on radiation and health [5.5]. The variability in the results of the post-Chernobyl studies can be explained by many factors – from the selection of geographical areas, to the size of populations and the quality of medical diagnosis. But the post-Chernobyl studies, when combined with other data on the risks of low level radiation, provide an argument that there exists a mechanism whereby ill health may be induced at lower dose rates than the current risks estimates project. The Agency should have regard to this recent evidence as it begins to quantify the level of error within the current dose risks

estimates set by NRPB/ICRP.

Finally, before determining these applications, the Environment Agency must resolve the issues regarding the impacts of low-level radiation on health [5.6]. The Agency must impartially assess this new evidence to see if it has a bearing on it's regulatory functions, and make the results of those deliberations available to the public. In particular:

- Whether the current risk estimates upheld by NRPB/ICRP are wholly correct, or whether there is uncertainty about their precision – particular in the light of the reassessment of Japanese bomb-survivor data;
- Whether the current methodology behind NRPB's/ICRP's risk estimates recognise the varied nature of the biological mechanisms involved in radiation exposure – in particular evidence relating to the *bystander effect*, *genomic instability* and the *second event theory*;
- Whether the variability in epidemiological studies on the effects of low level radiation are due to random or systematic errors in the source data on which they are based, or whether there is a likelihood that there are underlying trends which cannot be resolved due to the statistical limitations of the methodology involved; and
- Whether there is sufficient evidence to support the assumption that the regulation of discharged to protect humans will protect wildlife, or whether there is sufficient evidence to believe that current ecological risks estimates are inaccurate.

Whilst NRPB may be the government body charged with advising on matters of radiological protection, the NRPB's advice cannot remove the obligations put upon the Agency under their statutory obligations to have regard to the best scientific evidence [5.6]. Also, whilst the Agency may adopt a 'wait and see' position in relation to these applications, the release of radioactivity is one instance where a precautionary approach is essential.

There is no viable clean-up or remediation measure for radioactive contamination on the scale produced by the Magnox reactors and B205 at Sellafield. Therefore, in terms of the precautionary principle, the Agency do not require complete proof that current dose risk figures are incorrect before acting to achieve lower discharge levels [5.6]. In terms of how big a cut the Agency should enact, that again should be a precautionary figure based upon the varying estimates of error within the current figures. In our view the Agency should seek to cut emissions by a factor of 150 to 250 times.

If the Agency proceed in determining these applications without clarifying the validity of the risk factors on which the Agency's judgement is based, then those opposed to the granting of these applications may seek a review of the Agency's decision.

Site specific issues

There are a large number of modifications suggested to the draft authorisations dealing with site specific issues [6.1 to 6.9]. We request that the Agency consider all these requests and give effect to them.

In conclusion

We welcome the opportunity to comment on these draft authorisation. However, in our view, there is a large body of work still remaining to be completed in terms of the legal, procedural and technical issues. Some are minor modifications. Many go right to the heart of the justification of the operation of these sites, and require that the Agency consider particular legal blocks that may prevent the determination of these applications. We request that, as part of the decision documents, the Agency gives a clear explanation of all these issues, together with the reasons why the Agency could/could not accept our objections.

Finally, please note that, should ground arise, then interest has been expressed in clarifying these issues through a judicial review. Once again, we would wish to stress that in order to avoid this potentiality we are prepared to meet and discuss these issues if the Agency so wish.