

SAFEGROUNDS DEBATE PAPER

*Perspectives on the health risks from low levels of
ionising radiation*

David Collier

SAFEGROUNDS Debate paper. Perspectives on the health risks from low levels of ionising radiation

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Perspectives on the health risks from low levels of ionising radiation

SAFEGROUNDS documents generally represent consensus guidance on best practice on the management of radioactively and chemically contaminated land on nuclear and defence sites in the UK. However, SAFEGROUNDS is not a scientific committee, but it is a forum where individual stakeholders express their views and opinions, although agreement may not be reached on every topic. The aim is to build consensus around common needs and concerns but no one stakeholder's views take precedence over others' legitimate needs or concerns in the process, provided that the process has been properly conducted.

Where consensus cannot be achieved, the role of SAFEGROUNDS is to raise awareness of the differences of view and encourage resolution through appropriate channels rather than make its own judgements. One of the topics is the health risks from low levels of ionising radiation and so SAFEGROUNDS invited four authors to contribute debate papers for publication on the website as part of the awareness raising process.

Unlike SAFEGROUNDS guidance documents, the purpose of these four debate papers is to explore differences in view rather than areas of agreement. They are not intended as consensus papers, and have not been endorsed by the Steering Group. In each case individual members may well disagree with some of their contents.

The first three debate papers were independently written by members of the SAFEGROUNDS Project Steering Group (see <www.safegrounds.com/psg.htm>). Although there are naturally conflicts between papers, each can be taken as fully representing the views of the authors' organisation.

- Shelly Mobbs, the Health Protection Agency
- Richard Bramhall, the Low Level Radiation Campaign
- Paul Dorfman, Warwick University, on behalf of the Nuclear Consultation Group.

This fourth paper was written by David Collier, an independent consultant. Its purpose is to offer a framework for understanding different perspectives on the potential impact on human health of levels of ionising radiation below current regulatory limits. It attempts to summarise the key points from the three position papers and the main differences in perspective, but is not a substitute for them. SAFEGROUNDS encourages all those seeking an understanding to also read the source documents, which are concise and written to be accessible to a wide audience, and are supported by detailed references to the literature.

Although drafts of this paper were reviewed by the other debate paper authors to help ensure the positions being expressed had been properly understood, the subsequent analysis of the competing arguments is that of the author alone. It was commissioned by CIRIA (SAFEGROUNDS managers) but should not be taken as representing the views of CIRIA or any SAFEGROUNDS member organisation.

It was also the author's decision to set the issues out side by side without commenting explicitly or implicitly on their validity, on the basis that it is a guide to the arguments and not an assessment of them. This approach has value but means that consensus support for the publication of the paper from all sides of the debate could not be obtained. CIRIA recommends reading the comments overleaf from the other three debate paper authors before reading the paper.

Disclaimer

This summary document does not constitute consensus-based guidance and should not be taken as representing the views of any specific organisation. Readers seeking definitive views should refer to the individual papers. Readers are also reminded that users of SAFEGROUNDS guidance should use ICRP dose coefficients in their risk assessments for the regulators.

Remaining areas of disagreement

The main residual points of concern relating to this document are set out as follows:

HPA statement

HPA is unable to endorse this summary document primarily because it unavoidably gives a misleading view, leaving the uninformed reader to question the strength of epidemiological and experimental data providing the scientific basis for the ICRP protection system. The ICRP protection system is accepted by the majority of scientists working in this area and is implemented in regulatory systems worldwide. In attempting to provide a balanced account of the views submitted by the three members of the SAFEGROUNDS Steering Group, the summary document does not do justice to the substantial body of evidence on radiation risks, accrued over many decades, providing an international scientific consensus. The report does not present a detailed scientific review of the data and so it cannot be used to resolve the debate or provide recommendations.

Low Level Radiation Campaign statement

The dialogue failed to reach consensus on the overview because HPA felt it gave equal weight to the arguments. HPA argued that the vast majority of informed opinion world-wide endorsed the ICRP's approach to quantifying risks. As LLRC consistently replied, in making this objection HPA is applying cultural rather than scientific considerations; the weight of opinion is irrelevant – scientific method requires that a single credible piece of evidence that falsifies the predictions of a theory is enough to destroy the theory. There is an abundance of such evidence and the overview illuminates some key issues in this complex field. As such it is a useful resource for dialogues in which, as experience shows, industry representatives tend to believe the science they have learnt is more reliable than it really is and that public worries about health detriment at low levels of contamination are irrational.

Nuclear Consultation Group

Despite the key nature of the debate, the institutional definition of anthropogenic low level radiation (LLR) risk (that LLR is relatively safe) is by no means agreed. In fact this risk definition remains highly controversial and open to critical analysis. This debate runs parallel to, and is preconditioned by, other discussions concerning questions about whether or not radioactive waste can be disposed; the relative costs and benefits of nuclear powered energy in a warming world; or the value of precaution when considering low-probability high-impact risks under conditions of scientific uncertainty.

1 Introduction

- 1.1 A significant feature of the long-running SAFEGROUNDS process has been its success in retaining a broad range of stakeholders. This is largely because participants see the development of good practice guidance for managing contaminated land as a politically neutral moral imperative arising from past practices. The only topic where views within the SAFEGROUNDS Project Steering Group (PSG) diverge significantly is the estimation of risk from human exposure to low levels of radioactivity. In 2005 the differences of opinion were, to a limited extent, accommodated in an appendix to SAFEGROUNDS' first risk assessment document. Using a tabular format, it laid out risk coefficients based on three views and acknowledged that the practical solutions arising from applying the different coefficients might tend to converge (for more information go to: <www.safegrounds.org/guidance.htm>).
- 1.2 The PSG recognise that all the available sources of radiological protection advice are discretionary. However, in the regulatory context, regulations often specify the dose coefficients that should be applied in risk assessments, and these are based on consideration of the radiological protection advice. The appropriate dose coefficients for UK are specified in the EC Basic Safety Standards, and this is implemented in UK by the Ionising Radiation Regulations 1999 and Radioactive Substances Act 1993 (now incorporated into the Environmental Permitting Regulations 2010 in England and Wales). The dose coefficients specified in the EC BSS are the ones recommended by ICRP, and therefore the users of the SAFEGROUNDS guidance have to use the ICRP dose coefficients in their risk assessments for the regulators.
- 1.3 However, the PSG considers that users of the guidance, many of whom are likely to be legacy owners responsible for complying with environmental protection standards, may be unsure about whether the uncertainties and knowledge gaps associated with radiation risk estimates affect their deliberations and decisions. It was therefore felt that it might be helpful to inform users about the differences of opinion so far as they apply to land management, and also to set out the theoretical considerations underlying the different opinions and the radiobiological and epidemiological evidence which is adduced to support them.
- 1.4 SAFEGROUNDS asked for initial position statements from the proponents. These were then passed to the author of the current paper to extract the points of agreement and disagreement and elucidate them in a narrative of moderate length, with a consistent style and in accessible language, referencing out to supporting evidence bases where necessary.
- 1.5 It should be noted that the three position papers do not cover the full range of perspectives on the issues. In particular, there was no position paper that supported the view that there are 'safe thresholds' for exposure to ionising radiation (ie a level of exposure to ionising radiation below which radiation risks are zero).
- 1.6 The purpose of this paper is to offer a framework for understanding some of the different perspectives on the potential impact on human health of levels of ionising radiation below current regulatory limits. It offers no position of its own and does not seek to resolve or judge between competing positions, but it references and seeks to relate three position papers specially drafted by:
 - Richard Bramhall, Low Level Radiation Campaign (Bramhall, 2010)

- Paul Dorfman, Warwick University, on behalf of the Nuclear Consultation Group (Dorfman, 2010)
- Shelly Mobbs, Health Protection Agency (Mobbs *et al.*, 2010).

All are available on the SAFEGROUNDS website <www.safegrounds.com>.

2 Risks from radiation

- 2.1 High doses of radiation may lead to serious injury or to death within a relatively short time of exposure. However, below a dose threshold of around a few sieverts these serious “deterministic” effects do not occur and radiation dose leads to an increased risk of “stochastic” effects, predominantly cancer but also an assumed risk of hereditary effects. It is established that the increased risk of disease depends on a complex range of factors, including the size and nature of the dose received and the characteristics of the person exposed.
- 2.2 Epidemiology is generally agreed to provide good information on risks of cancer induction at high and moderate doses, with consistent data for chronic and acute exposures to external sources of radiation exposure. The current majority view is that there is no “safe threshold” below which exposure to ionising radiation cannot cause potentially lethal damage, but radiation biology and epidemiology are less conclusive at lower doses and their interpretation more contested.
- 2.3 Radiological protection has consistently aimed to: a) prevent serious injury by keeping doses below thresholds for deterministic effects, and to b) limit the increased risk of stochastic effects, attempting to balance the risk against social and economic benefits. However, information and concern about lower levels of radiation has emerged that could not be taken into account from the start of the nuclear era. In consequence, historic releases and exposures have been permitted which would now be considered unacceptable by Regulators and the public.
- 2.4 All three supporting papers agree that such sources and exposure to them must be regulated. Where positions differ is primarily in the interpretation of the epidemiological, experimental and theoretical evidence concerning the relationship between the nature and intensity of exposure and the risk to human health. This leads to differences of view as to whether discharges from nuclear plant or contamination levels have in the past, or have the future potential to, cause an unacceptable health risk, even though they comply with current regulatory limits. The level of risk commonly considered to be acceptable and the process of deriving regulatory limits is described in an HSE report (para 118 to 149 of HSE, 2001).
- 2.5 Broadly speaking, the Health Protection Agency (HPA) paper discusses why it and international agencies generally think that, if properly managed, discharges within the current regulations do not cause an unacceptable health risk. HPA supports the use of the ICRP protection system in the UK. Dr. Dorfman emphasises the concerns and uncertainties associated with current institutional radiation protection standards and argues for a much more precautionary approach. The Low Level Radiation Campaign (LLRC) supports alternative risk assessment approaches in some areas. It suggests that current risks are being significantly underestimated – particularly in respect of “internal emitters” – and that the ICRP concept of dose is fundamentally flawed.

Each of these positions is argued and supported with references in the three source papers based on interpretation of evidence and knowledge acquired within scientific contexts.

3 Policy development and regulation

- 3.1 In most cases, it is not the purpose of this overview paper to discuss the degree to which one or another position commands support – the authors of the three papers provide this – but some clarity about institutional roles is required.
- 3.2 Current institutional scientific knowledge comprises a large body of epidemiological, experimental and theoretical evidence, which is processed through review and advisory bodies and used by government to set environmental and exposure levels, enforced by regulators. They are reflected in energy policy and regulatory decisions related to (for instance) nuclear power and radioactively contaminated land.

Sources of advice

- 3.3 The International Commission on Radiological Protection (ICRP) is funded by its sponsoring governments via national and international bodies with an interest in radiological protection. It offers recommendations to regulatory bodies and these recommendations generally form the basis for radiation protection legislation in Europe and the rest of the world.
- 3.4 ICRP recommendations are based on its own committee assessments and scientific information from UNSCEAR (the United Nations Committee on the Effects of Atomic Radiation), which was established by the UN in 1955 to assess and report levels and effects of exposure to ionising radiation.
- 3.5 In the UK, one of the functions of the Health Protection Agency is the provision of information and advice on radiation protection of the community from risks connected with radiation. It reviews the available data and advises UK bodies such as the HSE and Environment Agency with responsibility for protection against radiation on the applicability to the UK of recommendations issued by ICRP.
- 3.6 Other organisations and individuals also provide advice and guidance from a range of perspectives. In particular, the three submissions refer to the ECRR. The European Committee on Radiation Risk (<www.euradcom.org>) is composed of independent scientists and was formed in 1997 following a conference on European Commission proposals to alter standards for the free release of radioactive substances. Its remit is to consider all available scientific evidence. ECRR is sceptical of ICRP's approach and has published alternative recommendations and reports on the effects of the Chernobyl accident.

Areas of contention

- 3.7 There are three central areas of contention that apply to institutional bodies and those offering alternative perspectives, concerning:
 - the validity of the institutions making the judgements and their ability to be objective
 - the conclusions they reach when considering specific evidence that might indicate the level of risk
 - the models and approaches used to underpin their guidance.
- 3.8 The three source papers focus for the most part on the last two areas, ie assessment of the science and models, but they also address institutional validity.

- 3.9 The LLRC paper notes that ICRP and the other bodies from which ICRP draws information have been subject to a range of criticisms, including the significant overlaps of personnel between national and international bodies. The allegation is that they are not sufficiently independent of what might be characterised as a long-standing and significant international investment in the current status quo.
- 3.10 In contrast, the HPA argues that ICRP is a well-regarded international professional body with formal relationships with the EU and UN organisations. It considers that the way in which the ICRP and UNSCEAR are constituted and go about their work is appropriate and generally endorses the adoption of their recommendations in UK legislation.
- 3.11 The scientific debate has continued for a number of years and most of the scientific issues discussed in this document were discussed by CERRIE, a scientific advisory committee established by the UK Government in 2001, following concerns about the risks of internal radiation. Its remit was to consider the present risk models for radiation and health that apply to exposure to radiation from internal radionuclides in the light of recent studies and any further research that might be needed.
- 3.12 CERRIE had 12 members with a wide range of views: HPA and Richard Bramhall were members, and Paul Dorfman was a member of the secretariat. The report describing the findings of the committee was published in 2004 (CERRIE, 2004) but two members of the committee (Busby and Bramhall) disagreed with the conclusions and published a separate minority report (Low Level Radiation Campaign, 2004). These two reports are referred to as the CERRIE majority and minority reports in this document.

4 Insights from epidemiology

A-Bomb survivors and other groups

- 4.1 The links between radiation at higher levels and cancer (including leukaemia) are based on epidemiological studies on Japanese atomic bomb survivors and other groups and are not the subject of this paper. At more moderate doses, the available evidence generally provides good information on the risks of cancer induction, though there is disagreement between HPA and LLRC as to whether the data for chronic and acute exposure is consistent in respect of both internal and external radiation: HPA's paper argues that it is; LLRC's argues that it is not.
- 4.2 The links between radiation and cancer at levels that might be characterised as "low level" have also been investigated through epidemiological studies on atomic bomb survivors and other groups. Other effects, including heart and immune responses, have also been postulated. The three source papers discuss the results and contest the conclusions in both cases.
- 4.3 The HPA considers that epidemiology has little prospect of providing direct risk estimates around natural background level or for exposures at low doses of a few mGy or less that this is because: (a) radiation is a weak carcinogen and the effect is too small to detect directly, and (b) we are all exposed to natural background radiation at around this level which will mask any effect. However, studies of bomb survivors and others allow risk to be estimated sufficiently reliably to underpin current regulatory limits. So, HPA concludes that low levels of radiation are not a significant risk to public or radiation worker health.
- 4.4 Dr Dorfman, however, concludes that current institutional radiation protection standards do not provide this confidence because of: (a) the inherent limitations of epidemiology, (b) data and methodological limitations (elements of key bomb survivor studies demonstrate significant methodological flaws), and (c) they do not take into account the potential that low levels of radiation have their impact in synergistic conjunction with carcinogens or other environmental factors. Given these factors and fundamental caveats relating to the ICRP dose concept, a more precautionary approach is required.
- 4.5 LLRC considers that studies claimed in support of the current standards are flawed. Its paper explains its view that: (a) survivors' data are an unsatisfactory basis for estimating the effects of internal contamination in particular and are generally recognised as such, (b) ICRP fails to take into account relevant information, and (c) alternative analyses suggest that the true level of risk is much higher for some types of exposure.
- 4.6 Risk factors derived from A-bomb survivor data apply to short, homogeneous, large external doses of gamma radiation at a high dose rate. ICRP applies them in all situations, including those at the opposite extreme in almost all respects: namely highly heterogeneous, low dose exposures to charged particles at low dose rates over protracted time periods.
- 4.7 All three source papers recognise that risk factors and their underpinning models are an important source of uncertainty in dose and risk estimates and that there are only a few epidemiological studies on internal emitters. However, the HPA paper states that the best direct evidence still shows risk estimates consistent with those from the A-bomb survivor study and these risk factors are the best available. Dr Dorfman and the LLRC conclude otherwise.

Chernobyl data

- 4.8 All three papers cover the results of post-Chernobyl and other epidemiology studies and HPA and LLRC support their arguments with detailed descriptions and referencing of source material.
- 4.9 Post-Chernobyl epidemiology has provided indications of increases in cataract and leukaemia among emergency workers and a clear and substantial increase in thyroid cancer incidence in persons exposed as children or adolescents.
- 4.10 While several studies in various European countries suggest that there has also been an increase in infant leukaemia following the accident, the HPA view is that interpretation is difficult and no firm conclusions can be drawn. LLRC contests this, and presents reasons why dose response is unlikely to be linear.
- 4.11 LLRC's position is that there is a large body of evidence from Chernobyl, which suggests that there are effects at low doses that are greater than can be accommodated within the ICRP model. It points out that it would be a circular argument to say that because the ICRP model of linear dose response and external/internal equivalence do not predict anomalous post-Chernobyl findings, then they cannot be due to radiation effects.
- 4.12 There is consensus between the three source papers that major inconsistencies between evidence and the ICRP (or any other) model would be cause for reassessment and might point to flaws in modelling approaches. However, there is disagreement over whether there are actually major inconsistencies in this context: LLRC's paper argues that there are, HPA's argues that there are not.
- 4.13 Dr Dorfman agrees with LLRC that some studies do show an apparent link to a range of health impacts in the region such as infant mortality and childhood leukaemia that cannot be explained if the accepted dose/response relationship and/or source term are correct.

Cancer and leukaemia incidence near UK nuclear facilities

- 4.14 The leukaemia excess around Sellafield, Dounreay and some nuclear weapons sites is generally accepted as fact. Recent studies in Germany (the "KiKK studies") also show excesses of solid tumours and leukaemia in children around nuclear plants. HPA and LLRC papers offer different assessments of the significance of these results and of the balance of scientific opinion.
- 4.15 The institutional view is that the results are not be explained by exposure to radioactive emissions and alternative explanations should be sought. The reasoning behind this position is set out in the HPA paper. Both LLRC and Dr Dorfman contend that key elements of the HPA's analysis are flawed and that radioactive emissions cannot be dismissed as the cause, especially if the basis for doing so is that the ICRP model is not consistent with the distribution of health effects.

Worker studies

- 4.16 LLRC's view, supported by Dr. Dorfman, is that studies which provide data on internally contaminated or potentially contaminated workers show enhanced risks. HPA argues that workforce studies on cancer risk are based on reliable dose data and their conclusions support the ICRP model and existing standards.

Bomb test data

- 4.17 LLRC states that no one has refuted the proposal that fallout caused the deceleration in the general, long-term reduction in infant mortality rates which was observed worldwide at the time of atmospheric weapons testing.
- 4.18 HPA and LLRC agree that fallout studies suggest an increased risk of childhood leukaemia due to this exposure. However, whilst LLRC argues that the increased risk is not consistent with the ICRP model, HPA argues that there is no evidence of a wave of excess cases of childhood leukaemia corresponding to the period of intense atmospheric testing and no consistent or sufficiently persuasive evidence that this risk has been seriously underestimated by standard risk models. LLRC argues that the data sets in the study cited in the HPA paper are problematic.

Key issues arising

- 4.19 Within this wider discussion of the level of risk from low levels of radiation, two issues were given particular attention in the three source papers: the nature of the dose response relationship, and the validity of ICRP models in respect of its treatment of internal sources. The main arguments are summarised in the following sections.

5 Dose response relationship

- 5.1 HPA suggests that there is little prospect of robust epidemiological data at the levels of exposure typically experienced by members of the public, and that it is therefore not possible to determine whether there is a “safe dose” threshold. However, based on its assessment of experimental data and understanding of biological mechanisms, the ICRP assumes a linear non-threshold (LNT) dose response relationship which leads to a recommendation that the overall risk of fatal cancer in a population exposed to low doses and dose rates can be taken to be five per cent per Sv.
- 5.2 The HPA view is that LNT is the best approach on current evidence for radiation protection purposes and is essential for the operation of the current protection system, allowing the addition of external and internal doses of different magnitudes, with different temporal and spatial patterns of delivery. However, they include references to alternative interpretations that receive support from authoritative sources, including the existence of thresholds for particular cancer types and hormetic effects in which low doses of radiation have a protective effect on cells.
- 5.3 The LLRC argues that, on the contrary, properly designed studies can be and have been done. Its view is that LNT is used for pragmatic reasons but considers that credible studies indicate the dose dependency of radiation effects may be non-linear, non-monotonic, and poly-modal. Over certain dose ranges low level exposures may be orders of magnitude more effective with regard to their impact on an organism or on a population than suggested by LNT. So its view is that the ICRP position is untenable.

6 Internal emitters and radiation biology

- 6.1 In the 1940s and early 1950s, there was a move towards the use of Japanese atomic bomb survivor epidemiology to gauge risk as described above, and an assumption was adopted that external and internal radiation could be summed to give risk-related dose figures. This is an oversimplification, but opinions differ about the extent to which this approach and the way it is managed within assessment methodologies underestimate true level of risk (LLRC and Dr. Dorfman) or represent a reasonable approach for protection purposes (HPA).
- 6.2 All three source papers agree that more research is needed to understand radiation risks at low doses, including risks from internal emitters, and that interesting findings are emerging on non-targeted effects of radiation, including genomic instability and bystander effects. Epidemiological studies identifying non-cancer effects of radiation exposure will need to be followed by mechanistic studies in order to understand their implications for risks at low doses.
- 6.3 There are substantive differences between the position papers on the validity in the meantime of the ICRP absorbed dose concept, which allows the risks from exposures to external irradiation and internal radiation from radionuclides incorporated in the body to be added to give a total dose that relates to the risk to an average person in a population. While absorbed dose (in gray; Gy) is calculated using biokinetic and dosimetric models, effective dose (in sievert; Sv) is a risk-related quantity for use in radiation protection which takes account of the effectiveness of different radiations in causing cancer using radiation weighting factors
- 6.4 The LLRC contends that the number and complexity of the biological effects of differing qualities of radiation discussed in its paper means that this aggregation of radiation from internal and external sources is too much of an oversimplification. It recognises that the ICRP approach to heterogeneity may be pragmatic but says that to claim that it has a justified scientific basis is a value judgement that it does not support. So the LLRC and others sceptical of the ICRP approach support the application of the provisional precautionary weighting factors proposed by the European Committee on Radiation Risk (ECRR) in the calculation of the subjective quantity, effective dose, as an alternative basis for regulation. The LLRC paper states that the general ECRR stance on uncertainty and lack of knowledge about effects of internal emitters has received support from several published peer reviewed sources.
- 6.5 HPA agrees that there are a number of uncertainties in the estimation of risks from radiation exposure but believes that they are not as large as claimed by those wishing to challenge UNSCEAR risk estimates and the ICRP protection system. It suggests that risks from internal emitters are acceptably well understood and may actually, in some cases, be overestimated by ICRP. It does not agree with the ECRR's assessment of epidemiological studies and does not believe the methodology has a sound scientific basis.

7 Mechanisms

- 7.1 LLRC and Dr. Dorfman point to a range of potential mechanisms that give rise to doubt and lead them to conclude that the risks from internal emitters are significantly greater than assumed by the ICRP averaging model include the following.
- there is a “bystander effect”, whereby cells proximal to other cells insulted with very low-levels of radiation show an unexpected sensitivity to mutation. This would define a larger target for radiation effects than assumed by ICRP
 - genomic instability suggests a means by which effects may be manifested across generations, although the detailed mechanisms are not yet clear. This would again define a larger target for radiation effects than assumed by ICRP.

LLRC also suggest further novel mechanisms:

- epidemiological and other data indicate that Uranium has anomalous radiological toxicity despite its low radioactivity, possibly mediated by the “secondary photoelectron effect” in combination with the affinity between Uranium and the DNA molecule
 - there is a possibility that “Bragg effect” dead cells have significant implications for the development of clonal damage.
- 7.2 HPA argues that the secondary photoelectron effect and the Bragg effect are of minor importance. It acknowledges that interesting findings are emerging on non-targeted effects of radiation, including genomic instability and bystander effects, but it does not believe that anything to date invalidates the use of the ICRP model or risk factors. It also notes that although there is no direct information on hereditary effects in humans, ICRP’s estimate of radiation detriment includes a component (about 10 per cent) for hereditary effects, estimated on the basis of animal data.
- 7.3 The LLRC says there are large knowledge gaps and uncertainties that should be urgently researched but it suggests the risk agencies have declined to fully address them. HPA says that, on the contrary, it fully supports the need for more research to understand radiation risks at low doses, including risks from internal emitters.

8 Implications

- 8.1 Radiation doses to the public from discharges from nuclear installations are extremely small compared with doses from natural background and from medical procedures.
- 8.2 The UK average annual dose of 2.7 mSv is made up of doses from naturally occurring and artificial (man-made) radiation. The greatest contribution comes from naturally occurring sources, giving an average annual dose of 2.2 mSv. The annual dose from natural background in the UK ranges from less than 2 mSv to greater than 200 mSv. These figures are not contested in the source papers, but the validity of the dose concept and of the model that translates doses into risk to the population are.
- 8.3 The “institutional” view is that there is no “safe threshold” for exposure to ionising radiation but that at the levels which follow from nuclear plant operation and contaminated land management the health risk to the population is very low. Based on ICRP figures, the total risk of fatal cancer in a population receiving a dose of 1 mSv would increase on average from about 25 per cent to 25.005 per cent. HPA considers that the ICRP approach remains valid and the right basis on which to base risk estimates and regulation.
- 8.4 The alternative view proposed by Dr Dorfman and LLRC is that the balance of evidence and new knowledge of mechanisms linked to internal emitters all support the view that the additional health risk is, on the contrary, potentially significant. The exposures of interest are probably those characterised by high ionisation density in or close to sensitive tissues. They suggest that in these cases neither the health outcomes nor mechanisms are properly modelled by ICRP and the error maybe up to several orders of magnitude. LLRC therefore propose the use of the ECRR weighting factors to modify current dose/risk estimates so that regulation may continue uninterrupted. However, the scientific validity of these ECRR weighting factors is contested by HPA.

9 Conclusion

- 9.1 This paper offers a framework for understanding different perspectives on the potential impact on human health of levels of ionising radiation below current regulatory limits. It attempts to summarise the key points from the three position papers and the main differences in perspective, but is not a substitute for them. SAFEGROUNDS encourages all those seeking an understanding to read the source documents, which are concise and written to be accessible to a wide audience and are supported by detailed references to the literature.

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