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Protection of the Environment under
Different Exposure Situations



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Aims and Scope

The International Commission on Radiological Protection (ICRP) is the primary body in protection against ionising radiation. ICRP is a registered charity and is thus an independent non-governmental organization created by the 1928 International Congress of Radiology to advance for the public benefit the science of radiological protection. ICRP provides recommendations and guidance on protection against the risks associated with ionising radiation from artificial sources widely used in medicine, general industry and nuclear enterprises, and from naturally occurring sources. These reports and recommendations are published approximately four times each year on behalf of ICRP as the journal *Annals of the ICRP*. Each issue provides in-depth coverage of a specific subject area.

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ICRP is composed of a Main Commission, a Scientific Secretariat, and five standing Committees on: radiation effects, doses from radiation exposure, protection in medicine, the application of ICRP recommendations, and protection of the environment. The Main Commission consists of a Chair and twelve other members. Committees typically comprise 10–15 members each.

ICRP uses Task Groups to prepare its reports. A Task Group is usually chaired by an ICRP Committee member and usually contains a number of specialists from outside ICRP. Thus, ICRP is an independent international network of specialists in various fields of radiological protection, and, at any one time, about two hundred eminent scientists and policy makers are actively involved in the work of ICRP. The Task Groups are assigned the responsibility for drafting documents on various subjects, which are reviewed and finally approved by the Main Commission. These documents are then published as the *Annals of the ICRP*.

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ICRP PUBLICATION 124

Protection of the Environment under Different Exposure Situations

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Editorial

A DECADE ON RADIOLOGICAL PROTECTION OF THE ENVIRONMENT

It is somehow fitting that this report should be published as we approach the 10th anniversary of *Publication 91* (ICRP, 2003), the International Commission on Radiological Protection's (ICRP) first publication on protection of the environment. It also marks 10 years since the International Conference on the Protection of the Environment from the Effects of Ionizing Radiation, held in Stockholm in 2003. The primary objective of the Stockholm conference was to promote the development of a coherent international policy on the protection of the environment from effects attributable to ionising radiation. It is worth briefly revisiting the findings of the Stockholm conference to fully appreciate how far we have travelled over the last decade.

The main finding of the conference was that time is ripe for launching a number of international initiatives to consolidate the present approach to controlling radioactive discharges to the environment, taking explicit account of the protection of species other than humans (IAEA, 2003). In specifying this, the international community gathered in Stockholm set expectations on a number of international organisations, including ICRP, as follows:

1. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) should continue to provide findings on the sources and effects of ionising radiation that can be used as the authoritative scientific basis for future international efforts in environmental radiation protection.
2. ICRP should continue to issue recommendations on radiation protection, including specific recommendations for the protection of non-human species.
3. The International Atomic Energy Agency (IAEA) should establish appropriate international undertakings, including international standards and mechanisms for their worldwide application, to restrict releases of radioactive materials into the environment over time, in order that not only humans but also the non-human component of the environment is protected adequately. IAEA should continue to foster information exchange by organising international meetings on this subject.

In the intervening period, UNSCEAR has published an annex on the effects of ionising radiation on non-human biota (United Nations, 2008); ICRP has published a series of reports that will be mentioned in more detail below; and IAEA, with other international organisations, has revised the International Basic Safety Standards that

define requirements to satisfy the fundamental safety objective of protecting people and the environment from harmful effects of ionising radiation (IAEA, 2011).

Other efforts at national and international level also nurtured the process of development of a system for environmental protection, notably the work promoted by the International Union of Radioecology (IUR, 2012). The European Commission's initiatives FASSET (Larsson, 2004) and ERICA (Larsson, 2008), and the US Department of Energy's Biota Dose Assessment Committee (US Department of Energy, 2002) also provided significant contributions.

In 2003, the system of radiological protection, as it related to the environment, was entirely dependent on the belief that the standards of environmental control needed to protect humans to the degree currently thought desirable will ensure that other species are not put at risk (ICRP, 1991). In *Publication 91* (ICRP, 2003), ICRP acknowledged that this system provided indirect protection of the human habitat, but that a more comprehensive approach to study the effects on, and thus the protection of, all living matter with respect to ionising radiation should be developed. This publication further identified the principles of environmental protection, and proposed a framework for assessing the impacts of ionising radiation on non-human species, based on a reference flora and fauna approach.

The 2007 Recommendations of ICRP (ICRP, 2007) effectively extended the system of protection to address protection of the environment, including flora and fauna, more explicitly. These recommendations explore the objectives of environmental protection and explain the basis for the proposed Reference Animals and Plants (RAPs), which are a small set of hypothetical entities that are representative of animals and plants present in different environments (terrestrial, freshwater, marine) and which form the basis of a structured approach to the assessment of exposures to, and effects of, ionising radiation.

The concept and use of RAPs was dealt with in more detail in *Publication 108* (ICRP, 2008), which contains information on the assumed biology, dosimetry, and available effects database for these entities. A range of Derived Consideration Reference Levels (DCRLs) were also proposed for each of the RAPs as numerical guidance for evaluating the level of potential or actual radiological impacts and as an input to decision making. These values were defined in terms of bands of doses within which certain effects have been noted, with a focus on those which may have some impact on the population structures of the animals and plants under consideration. In 2009, *Publication 114* was issued (ICRP, 2009), providing transfer parameters for the set of RAPs.

The present report, which results from a joint effort of ICRP Committees 4 and 5, consolidates the suite of ICRP recommendations on environmental protection and provides further guidance on their application. It places the assessment of potential impacts on animals and plants within the existing system of radiological protection. In particular, it provides a mechanism for allowing environmental considerations to be

included in the identification of the best management options, as part of the optimisation process. At the planning stage, the approach will allow practical environmental considerations to be part of decisions about minimising the possibility of potential exposures. During normal operations, the approach will allow explicit demonstration of the level of radiological protection of flora and fauna, as part of the process of routine assessment and surveillance. The approach will also allow impacts on animals and plants to be assessed and managed in a more informed manner in seeking solutions to existing exposures as a result of past practices or accidents. Finally, it will allow the significance of the impact of a severe emergency situation on animals and plants to be assessed where appropriate. Thus, this approach allows protection of the environment to be considered in a more explicit manner in all the exposure situations, and provides an objective basis for better management of environmental resources.

It is worth noting that, although this report represents a significant milestone in the development of an approach for environmental radiation protection, its publication does not represent the end of the story. The ICRP framework and its application are open to future inputs from the scientific community. Indeed, ICRP recognises that protection of the environment is a complex issue and that its framework cannot be expected to solve all relevant issues immediately; after all, it has taken almost 40 years for the system of radiological protection for humans to reach its current state of development. It is anticipated that this approach will serve to provide a mechanism to inspire future scientific activities and to help define priorities. Its strength is that it can serve as a starting point to assess and manage the radiological impact on non-human species, and as a concrete reference against which to analyse the need for expansion or alternative solutions to the concept of RAPs in the future.

In developing its framework, ICRP has successfully navigated a difficult course between a range of external and internal expectations and drivers. The external situation has been tempered by the markedly different opinions among members of the radiological protection community, particularly in the early stages. Many argued that no change in the existing system of radiological protection was necessary given that humans and the environment were already adequately protected by current safety levels, and that the existing hypothesis has been confirmed by numerous studies in the context of normal exposures. The main driver for change has been the increasing awareness in society, since the 1990s, of the need for equitable consideration of economic development and environmental protection, which has been reflected in the establishment of formal international and national legal instruments related to, for example, conservation, sustainability, and biodiversity. In light of this, ICRP has responded to growing international consensus that, for certain situations, methods that allow explicit evaluation of the potential impact of releases of radioactivity to the environment are a necessary input to decision making.

In undertaking this work, ICRP also specified a number of internal conditions that are worthy of note. It determined that complexity of the framework for protection of

the environment, including the assessment of impacts on flora and fauna, should be commensurate with the level of risk, such that its application would facilitate the best use of appropriate resources and avoid the expenditure of unnecessary effort. ICRP also specified that the approach should be compatible with both the existing system of radiological protection and current methods for assessing the effects of other environmental stressors. Finally, ICRP set out to develop a method that was based on best use of the current level of scientific knowledge, while allowing the new information to be collected and incorporated into the approach in the future.

At the end of an eventful decade, with the publication of the present report, organisations with the mandate to develop further international and national standards have the basis for developing practical guidance and standards that allow the environment to be considered in a more explicit manner that ultimately reinforce the system of radiological protection.

On a completely different subject, this issue of *Annals of the ICRP* is the first to be published by SAGE UK. From 1928 to 1959, ICRP reports, including those under ICRP's former name – International X-ray and Radium Protection Committee – were published as articles or on behalf of ICRP by other organisations. What later became known as *Publication 1* (ICRP, 1959) was the first volume issued by ICRP, published as a book by Pergamon Press. Eventually, ICRP moved to a journal format, producing *Publication 24* as Volume 1, Issue 1 of *Annals of the ICRP* in 1977 (ICRP, 1977). In 2004, Pergamon Press was acquired by Elsevier, who continued to publish *Annals of the ICRP* for many years, up to and including *Publication 123* (ICRP, 2013).

The move from Elsevier to SAGE was the result of a competitive process, and has been almost seamless thanks to the professionalism of both companies. It seems more like a move to SAGE than a move from Elsevier, with whom we continue to have very good relations. Examining the current issue, readers will see that we have not made any major changes in format to coincide with this change in publisher, and none are planned. It may be possible to detect a few minor style changes, but these are evolutionary improvements not unlike other small changes that have occurred over the last few years. ICRP looks forward to this new partnership with SAGE, together finding new and exciting ways to make it even easier for those with an interest in radiological protection to access the guidance and recommendations of ICRP.

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Protection of the Environment under Different Exposure Situations

ICRP PUBLICATION 124

Approved by the Commission in April 2013

Abstract—In this report, the Commission describes its framework for protection of the environment and how it should be applied within the Commission's system of protection. The report expands upon its objectives in relation to protection of the environment, in so far as it relates to the protection of animals and plants (biota) in their natural environment, and how these can be met by the use of Reference Animals and Plants (RAPs); their Derived Consideration Reference Levels (DCRLs), which relate radiation effects to doses over and above their normal local background natural radiation levels; and different potential pathways of exposure. The report explains the different types of exposure situations to which its recommendations apply; the key principles that are relevant to protection of the environment; and hence how reference values based on the use of DCRLs can be used to inform on the appropriate level of effort relevant to different exposure situations. Further recommendations are made with regard to how the Commission's recommendations can be implemented to satisfy different forms of environmental protection objectives, which may require the use of representative organisms specific to a site, and how these may be compared with the reference values. Additional information is also given with regard to, in particular, communication with other interested parties and stakeholders. Issues that may arise in relation to compliance are also discussed, and the final chapter discusses the overall implications of the Commission's work in this area to date. Appendices A and B provide some numerical information relating to the RAPs. Annex C considers various existing types of environmental protection legislation currently in place in relation to large industrial sites and practices, and

the various ways in which wildlife are protected from various threats arising from such sites.

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Keywords: Radiation; Exposure situations; Environmental protection; Biota

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PREFACE

At its meeting in Suzhou, China in 2010, the Main Commission approved the formation of a new Task Group reporting to Committees 4 and 5 on ICRP's approach to protection of the environment. This was undertaken because, although *Publication 103* (ICRP, 2007) had introduced a new environmental protection requirement into its recommendations [following on from *Publication 91* (ICRP, 2003)], *Publication 108* (ICRP, 2008) had made it necessary to demonstrate, explicitly, how the expanded ICRP framework held together collectively in a coherent manner. This was essential in order to articulate how more practical advice could be accommodated in the future within existing and anticipated regulatory frameworks.

It was also recognised that although *Publications 91* and *108* (ICRP, 2003, 2008) had collectively set out the ethics, values, and current science base underlying the Commission's environmental objectives, it was still necessary to explain how these new areas resided within the long-standing context of the Commission's principles of justification, optimisation, and the application of limits.

The membership of the Task Group was as follows:

R.J. Pentreath (Chair)	D. Copplestone	P. Strand
J. Lochard (Vice-Chair)	C-M. Larsson	M. Watanabe
D.A. Cool	J. Simmonds	

The corresponding members were:

A. Janssens	D. Oughton	G. Pröhl
E. Lazo	I. Outola	

D. Telleria was invited as an observer.

The Task Group met twice, on 12–13 June 2010 at STUK, Helsinki, Finland, and on 28–29 June 2011 at CEPN, Fontenay-aux-Roses, France, but worked mainly by correspondence. The explanation of how the Commission's approach to environmental protection relates to that of human radiation protection, and how the principles of justification, optimisation of protection, and application of limits apply to different exposure situations received the full endorsement of Committees 4 and 5 in Washington, USA in October 2011. Following public consultation, a small editing group met in Chilton, UK on 23–24 January 2013.

The membership of Committee 5 during the preparation of the report was:

R.J. Pentreath (Chair)	D. Copplestone	P. Strand
C-M. Larsson (Vice-Chair)	K.A. Higley	A. Real
F. Brechignac	K. Sakai	A. Ulanovski

The membership of Committee 4 during the preparation of the report was:

J. Lochard (Chair)	J.F. Lecomte	G. Massera
W. Weiss (Vice-Chair)	H. Liu	K. Mrabit
P.A. Burns	S. Liu	S. Shinkarev
D.A. Cool	A. McGarry	J. Simmonds
T. Homma	S.M. Magnusson	A.S. Tsela
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EXECUTIVE SUMMARY

(a) Within the Commission's overall framework for protection against ionising radiation, the Commission has now broadened its scope by introducing a new requirement, that of protecting the environment. The present report describes the Commission's framework for protection of the environment and how it should be applied within the Commission's system of protection.

(b) The Commission's aims in terms of environmental protection are to prevent or reduce the frequency of deleterious radiation effects on biota to a level where they would have a negligible impact on the maintenance of biological diversity; the conservation of species; or the health and status of natural habitats, communities, and ecosystems. The biological endpoints of most relevance are therefore those that could lead to changes in population size or structure. Due to the immense variety of biota, and their presumed response to radiation, any credible system needs to have some key points of reference that provide some form of auditable trail that links the basic elements of the framework together, or at least could do so if further data were forthcoming and it is feasible to obtain such data. The Commission therefore developed a small set of 12 Reference Animals and Plants (RAPs), plus their relevant databases, for a few types of organisms that are typical of the major environments. The RAPs were described to the generality of the taxonomic level of Family, because this is the highest taxonomic level at which the biological features of an animal or plant of relevance to the effects of radiation can be assumed to be relatively constant. They are essentially reference models.

(c) Derived Consideration Reference Levels (DCRLs) that are specific to each of the different types of RAPs have also been defined. A DCRL can be considered as a band of dose rate, spanning one order of magnitude, within which there is some chance of deleterious effects from ionising radiation occurring to individuals of that type of RAP. Thus, when considered together with other relevant information, DCRLs can be used as points of reference to inform on the appropriate level of effort that should be expended on environmental protection, dependent on the overall management objectives, the exposure situation, the actual fauna and flora present, and the numbers of individuals thus exposed.

(d) The Commission therefore recommends that DCRLs should be used under all circumstances where there is, or may be, an incremental environmental exposure of significance above the natural background locally experienced by the relevant biota. In planned exposure situations, the lower boundary of the relevant DCRL band should be used as the appropriate reference point for protection of different types of biota within a given area during the planning of controls to a source. Due to the possibility of multiple sources affecting the same biota, or for any residual exposures arising from previous sources, consideration also needs to be given to possible cumulative impacts.

(e) For existing exposure situations, and in emergency exposure situations where control of the source has not been obtained, if the dose rates are above the relevant DCRL band, the Commission recommends that the aim should be to reduce

exposures to levels that are within the DCRL bands for the relevant populations, with full consideration of the radiological and non-radiological consequences of so doing. If dose rates are within the bands, the Commission believes that consideration should be given to reduce exposures, assuming that the costs and benefits are such that further efforts are warranted. Thus, in the case of existing exposure situations, the DCRLs should be used as the criteria for mitigating environmental exposures.

(f) As the RAPs are, by definition, points of reference, it may also be necessary to identify representative organisms relevant to each situation. These may be extremely similar to RAPs or may be different. In some cases, there will be little choice in selection because this may have been undertaken previously by way of other existing legislation. Nevertheless, differences between such biota and the RAPs should be quantifiable in relation to their basic biology, dosimetry, or radiation effects, and such differences need to be noted and taken into account. The extent to which such factors need to be applied, and their relevant impact on the final decision, will depend on the nature of the implementation and application of the planning process relevant to protection of the environment. As other regulatory bodies are likely to be involved, such as those responsible for wildlife management, it is essential to have a clearly set out logical link between any radioactive releases and potential risk of biological effects (for which the RAP framework should be a starting point), and a clearly laid out strategy by which the relevant stakeholders can be engaged in the decision-making process.

(g) With regard to responding to an actual emergency event, or accidental release of radionuclides into the environment, consideration of environmental protection may not be an immediate priority, depending on the extent to which human exposures, or human food chains, are likely to be affected. However, even where human exposure concerns predominate, consideration should be given to the environmental consequences of the possible options available to achieve the adequate level of human protection.

(h) After the occurrence of an accident, the framework of the DCRLs, and the set of indicative population impacts relative to the doses they receive, may be useful in communicating the implications of the situation to stakeholders, particularly in relation to environmental conditions where humans have been removed from the area, and food chains leading to human exposure have been severed. The concept of such severe-effect reference levels is often used within the chemical industry. The Commission notes that this type of level could be considered to be approximately equivalent to a band of doses two orders of magnitude above the DCRL band. With the passage of time immediately following an accidental release, information can be conveyed to the public in terms of an assessment of the environmental situation relative to a predetermined reference point, and thus the results of mitigation actions, or simply the effect of natural events, can be readily assessed and evaluated.

(i) Wherever possible, protection of the environment from a source should complement controls to protect the public, and not add unnecessarily to its complexity. The Commission therefore believes that, having essentially clarified the basis upon which decisions relating to protection of the environment can be made by way of a

framework relating exposure to dose, and dose to effect, for different types of organisms (the set of RAPs), the demonstration of protection of both humans and non-human species as a result of normal planned exposure situations could well be integrated in a relatively simple manner, based solely on estimations (at the design stage) and measurements (during operation) of concentrations of radionuclides in the environment.

(j) The practical implementation of these recommendations will be kept under review by the Commission, and any future revisions will be made in light of this experience.