Journal of Environmental Radioactivity 133 (2014) 60–68

Contents lists available at ScienceDirect

Journal of Environmental Radioactivity

journal homepage: www.elsevier.com/locate/jenvrad

Demonstrating compliance with protection objectives for non-human biota within post-closure safety cases for radioactive waste repositories

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ARTICLE INFO

Article history:
Received 16 November 2012
Received in revised form
19 May 2013
Accepted 11 July 2013
Available online 9 August 2013

Keywords:
Non-human biota
Radioactive waste disposal
Environmental safety case
Post-closure safety case
Protection criteria

ABSTRACT

Over recent years, a number of approaches have been developed that enable the calculation of dose rates to animals and plants following the release of radioactivity to the environment. These approaches can be used to assess the potential impacts of activities that may release radioactivity to the environment, such as the operation of waste repositories. A number of national and international studies have identified screening criteria to indicate those assessment results below which further consideration is not generally required. However no internationally agreed criteria are currently available and consistency in criteria between countries has not been achieved. Furthermore, since screening criteria are not intended to be applied as limits, it is clear that they cannot always form a sufficient basis for assessing the adequacy of protection afforded. Typically, exceeding a screening value leads to a regulatory requirement to undertake a further, more detailed assessment. It does not, *per se*, imply that there is inadequate protection of the organism types at the specific site under assessment. Therefore, there is a need to develop a more structured approach to dealing with situations in which current screening criteria are exceeded. As a contribution to the developing international discussions, and as an interim measure for application where assessments are required currently, a two-tier, three zone framework is proposed here, relevant to the long term assessment of potential impacts from the deep disposal of radioactive wastes. The purpose of the proposed framework is to promote a proportionate and risk-based approach to the level of effort required in undertaking and interpreting an assessment.

1. Introduction

Over recent years, a number of approaches have been developed that enable assessments to be made of the potential environmental impact of releases of radioactivity through the calculation of dose rates to animals and plants (non-human biota or NHB). However, the applicability of these methods is complicated by the array of protection objectives applied; as acknowledged by the ICRP (2008) statement that, '*no simple or single universal definition of environmental protection is applied internationally and that the concept of environmental protection differs from country to country and from one circumstance to another*'. Nonetheless, the range of environmental protection goals are largely encompassed by the protection goal offered by the ICRP (2003) to '*safeguard the environment by preventing or reducing the frequency of effects likely to cause early mortality or reduced reproductive success in individual fauna and flora to a level where they would have a negligible impact on conservation of species, maintenance of biodiversity, or the health and status of natural habitats or communities*'.

The European Commission also recognise the need to formalise requirements to introduce protection goals for non-human species: the following wording is taken from the Draft EC Basic Safety Standard (European Commission, 2011).

> "Member States shall include, in their legal framework for radiation protection and in particular within the overall system of human health protection, provision for the radiation protection of non-human species in the environment. This legal framework shall introduce environmental criteria aiming to protect populations of vulnerable or representative non-human species in the light of their significance as part of the ecosystem." (Article 76)

> "Member States' competent authorities, when establishing authorised limits on discharges of radioactive effluents … shall also ensure adequate protection of non-human species. For this

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0265-931X/$ – see front matter © 2013 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.jenvrad.2013.07.005

purpose, a generic screening assessment may be conducted to provide reliance that the environmental criteria are met." (Article 77)

As indicated by the draft BSS, some form of criteria are required as a means of evaluating the level of risk posed to the environment. For example, screening values can be defined below which it can be concluded with a high degree of confidence that no significant adverse impacts will occur and that no further assessment is required. However, no environmental criteria or generic screening values are recommended within, or appended to, the BSS and appropriate actions to be taken in the event of exceeding a screening value are not indicated. In order to define screening or other criteria, appropriate protection goals, and dose rate values (or benchmarks) representative of these protection goals, need to be agreed (Howard et al., 2010).

A number of national and international studies have identified screening criteria. However there are no internationally agreed criteria and consistency between countries has not been achieved (Copplestone et al., 2010). In any case, since screening criteria are not intended to be applied as limits, it is clear that they cannot form a sufficient basis for assessing the adequacy of protection. For the purposes of this paper, a 'limit' represents a regulatory value that may not be exceeded and any such exceedance would therefore require measures to reduce exposure below the limited parameter or would otherwise be deemed unacceptable. Other 'criteria' represent risk based values. Typically, exceeding a screening criterion value leads to a regulatory requirement to undertake a further, more detailed assessment. It does not, *per se*, imply that there is inadequate protection of the organism types at the specific site under assessment. It follows, therefore, that even where a detailed assessment can be undertaken and where it results in a dose which exceeds the screening criteria, it need not imply that there is inadequate protection. Consequently, there is a need to consider what to do should a screening value be exceeded. This is particularly the case for 'post-closure safety assessments', which aim to evaluate the future impacts of radionuclide releases from radioactive waste repositories. Such assessments are complicated by a number of issues:

- Radionuclides released from radioactive waste repositories will be transported from the near-field, through the geosphere, to the biosphere either as gases or in association with groundwater movement over prolonged periods.
- Repository integrity, hydrogeochemical properties of each individual radionuclide and environmental conditions will determine the period over which release and subsequent transport to the biosphere occurs. Peak activity concentrations for individual radionuclides in the accessible environment may be encountered over many tens of thousands of years.
- The long periods over which releases of radioactivity to the environment may occur are consistent with evolutionary adaptation and habitat changes, such that species present at the time of waste disposal may differ from those to which exposure occurs.
- Climatic changes (natural and/or driven by human actions) over these timescales will affect the nature and structure of ecosystems and the species present (since different species vary in their tolerance to different environmental conditions).
- The nature of the assessments means that there is limited scope to refine input data through site-specific verification activities such as environmental monitoring.

Given the current need to develop safety cases (including 'post-closure assessments') when planning the construction of radioactive waste repositories, coupled with the absence of internationally agreed protection goals and criteria, there is a need to provide a conceptual framework that regulators and industry can use to structure dialogue with regard to safety case development. Acknowledging that there are ongoing international discussions which, it is hoped, will ultimately lead to international consensus, this paper contributes to these discussions by presenting an interim measure for application where assessments are required currently.

2. Approach to the development of a compliance framework concept

Screening dose rates may be expressed relative to all or some of the potentially exposed NHB (e.g. separate dose rates may be expressed for terrestrial or aquatic organisms or be generic to all ecosystems), may be based on different effects considerations and presented in units of Gy or Gy-derivatives (e.g. including weighting factors for different types of radiation). The unifying concept is that below a set screening dose rate, it is accepted that no further action is required to demonstrate that NHB have been protected adequately (see Fig. 1). In no cases have upper dose rates been identified which would automatically be regarded as unacceptable (i.e. no dose limits are imposed).

The approach represented by Fig. 1 is considered to be inadequate as a framework to demonstrate protection of NHB, and it is the inverse of the radiological protection philosophy advanced for people where, some variant on the ICRP concepts of justification, optimisation and limitation is generally accepted. In effect, this means that:

- all doses should be justified (i.e. the practice being introduced should offer a net benefit to society);
- all doses should be maintained As Low As Reasonably Achievable (ALARA), subject to economic, social and other factors, which include equitability of distribution between groups of people and across generations; and,
- no individual should be exposed above the relevant limit.

Some regulatory regimes (such as adopted in the UK) also recognise a lower dose level below which further reduction is not required; however, this remains subject to demonstrating that Best Available Techniques (BAT) are being implemented and this effectively does little more than recognise the changing balance of any cost-benefit argument as the benefits to be gained progressively decrease. The application of the upper and lower bands has been formalised by the UK Health & Safety Executive (HSE, 1992) as a Tolerability of Risk (see Fig. 2).

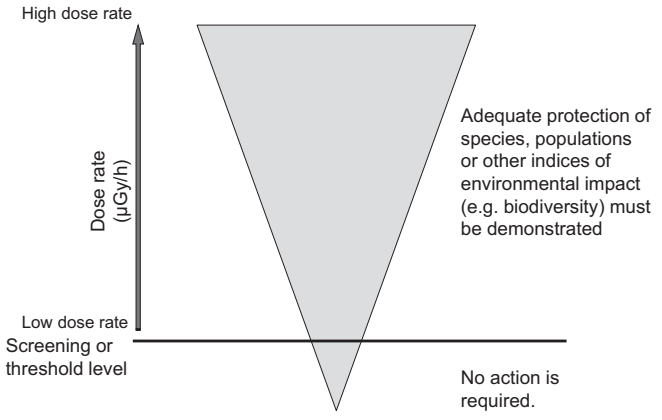

Fig. 1. Schematic approach to demonstrating protection of non-human biota.