Application of the Integrated Approach to Radiological Protection in Different Exposure Situations

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ICRP Committee 4
Chair of Task Group 105

Outline

- Radiological protection of the environment
- DCRLs & their application in planned, existing and emergency exposure situations
- Case studies
- Considerations for existing exposure situations with respect to the environment
- Lessons learnt
- Next steps

This presentation has neither been approved nor endorsed by the Main Commission of ICRP

ICRP Publication 103

2. THE AIMS AND SCOPE OF THE RECOMMENDATIONS

2.1. The aims of the Recommendations

(26) The primary aim of the Commission's Recommendations is to contribute to an appropriate level of protection for people and the environment against the detrimental effects of radiation exposure without unduly limiting the desirable human actions that may be associated with such exposure.

(27) This aim cannot be achieved solely on the basis of scientific knowledge on

ICRP Publication 103 – protection goals

of how decisions have been reached.

(28) Radiological protection deals with two types of harmful effect. High doses will cause deterministic effects (harmful tissue reactions, see Chapter 3), often of an acute nature, which only appear if the dose exceeds a threshold value. Both high and low doses may cause stochastic effects (cancer or heritable effects), which may be observed as a statistically detectable increase in the incidences of these effects occurring long after exposure.

(29) The Commission's system of radiological protection aims primarily to protect human health. Its health objectives are relatively straightforward: to manage and control exposures to ionising radiation so that deterministic effects are prevented, and the risks of stochastic effects are reduced to the extent reasonably achievable.

(30) In contrast, there is no simple or single universal definition of 'environmental protection' and the concept differs from country to country and from one circum-

ICRP103 (2007)

(30) ….aim is…preventing and reducing the frequency of deleterious radiation effects to a level where they would have negligible impact on the maintenance of **biological diversity**, the **conservation of species**, or the health and status of **natural habitats**, **communities** and **ecosystems**.

ICRP103

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ICRP103

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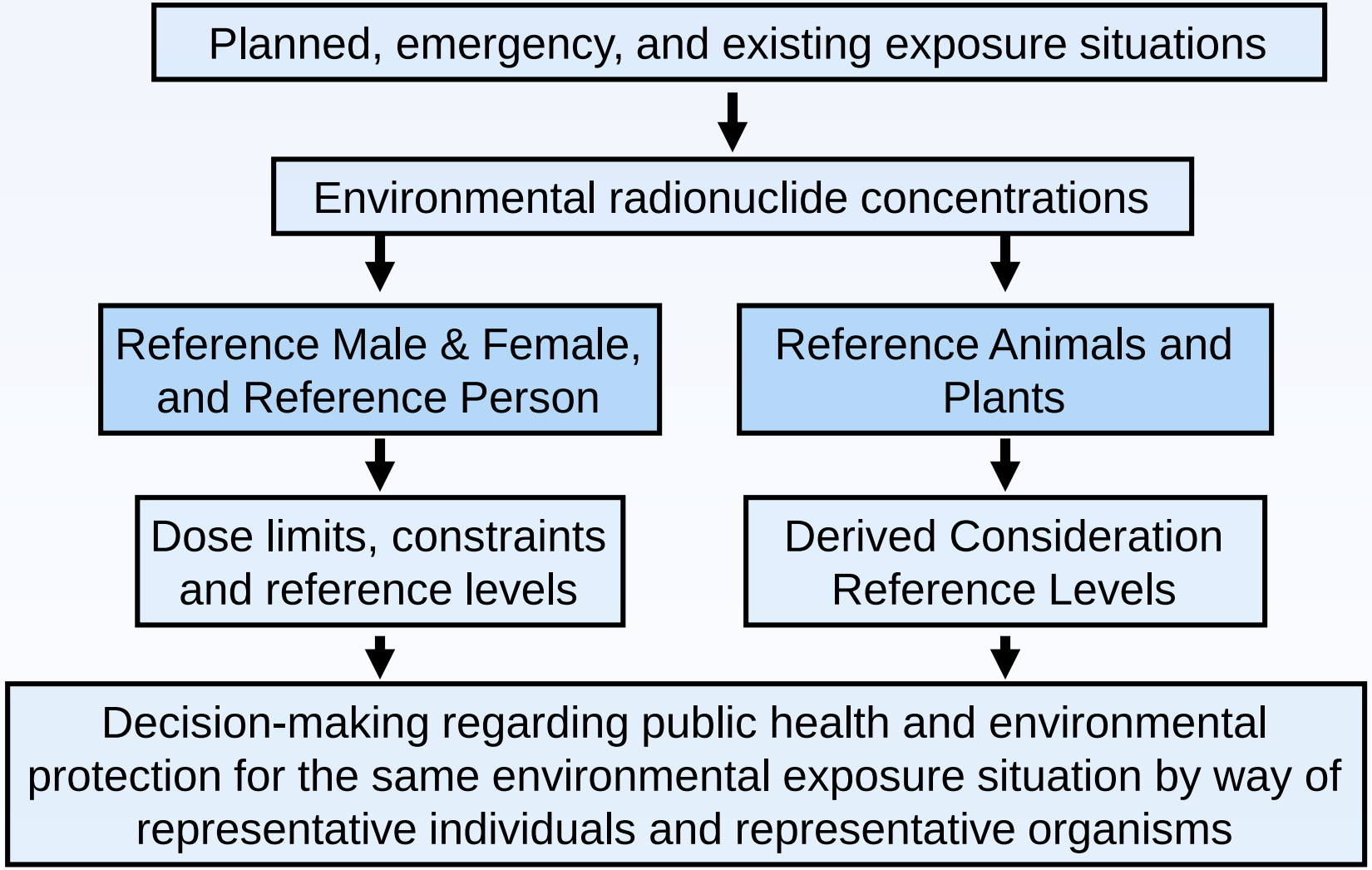
How has the system been built?

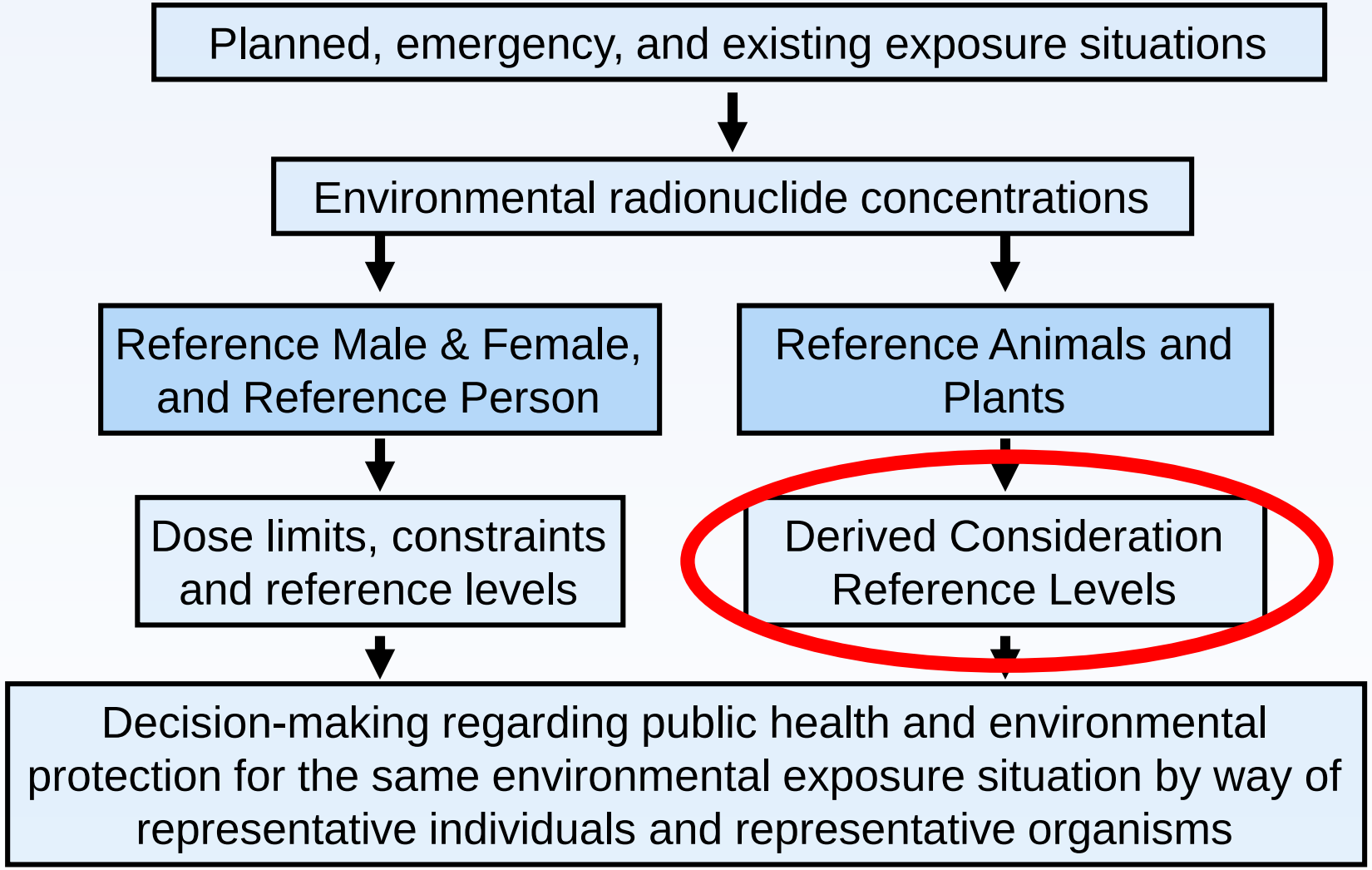

Planned, emergency, and existing exposure situations
Environmental radionuclide concentrations
Reference Male & Female, and Reference Person
Reference Animals and Plants
Dose limits, constraints and reference levels
Derived Consideration Reference Levels
Decision-making regarding public health and environmental protection for the same environmental exposure situation by way of representative individuals and representative organisms

ICRP 108 (2008)

WILDLIFE GROUP	RAP
Large terrestrial mammals	Deer
Small terrestrial mammals	Rat
Aquatic birds	Duck
Amphibians	Frog
Freshwater pelagic fish	Trout
Marine fish	Flatfish
Terrestrial insects	Bee
Marine crustaceans	Crab
Terrestrial annelids	Earthworm
Large terrestrial plants	Pine tree
Small terrestrial plants	Wild grass
Seaweeds	Brown seaweed

RAP selection

- Pragmatic
- Covering different ecosystems
- Example animals/plants
- Considering application as species of conservation interest
- Where possible geographic spread
- Allowing for transboundary (e.g. birds)
- Different lifestages
- Amount of available information
- Potential for future studies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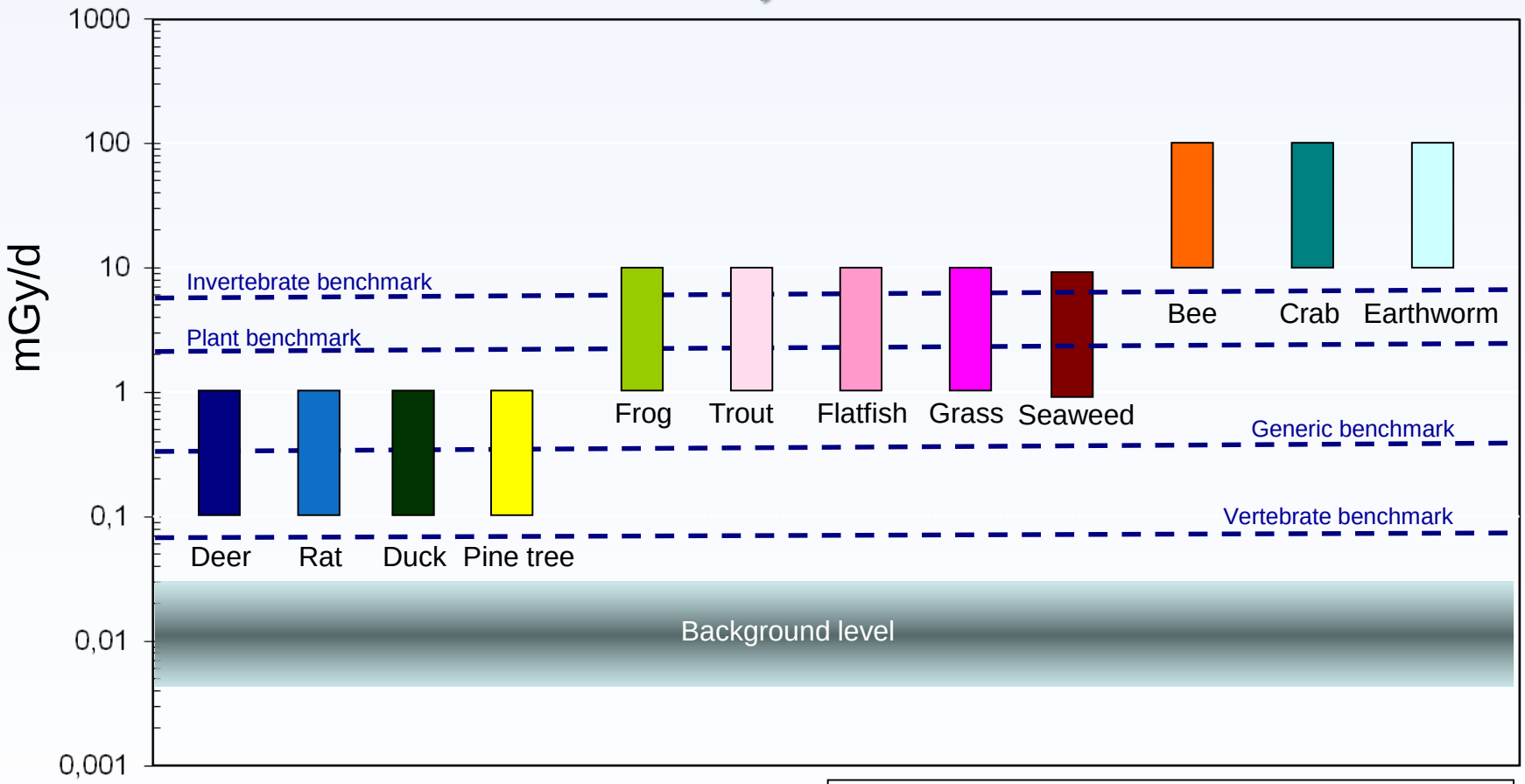
Derived Consideration Reference Levels (DCRLs)

- ICRP Publication 108:

- *"A DCRL can therefore be considered as a band of dose rate within which there is likely to be some chance of deleterious effects of ionising radiation occurring to individuals of that type of Reference Animal or Plant, derived from a knowledge of defined expected biological effects for that type of organism that, when considered together with other relevant information, can be used as a point of reference to optimise the level of effort expended on environmental protection, dependent upon the overall management objectives and the exposure situation."*

ICRP 108 (2008)
Derived Consideration Reference Levels, DCRLs



Benchmarks from other studies/systems

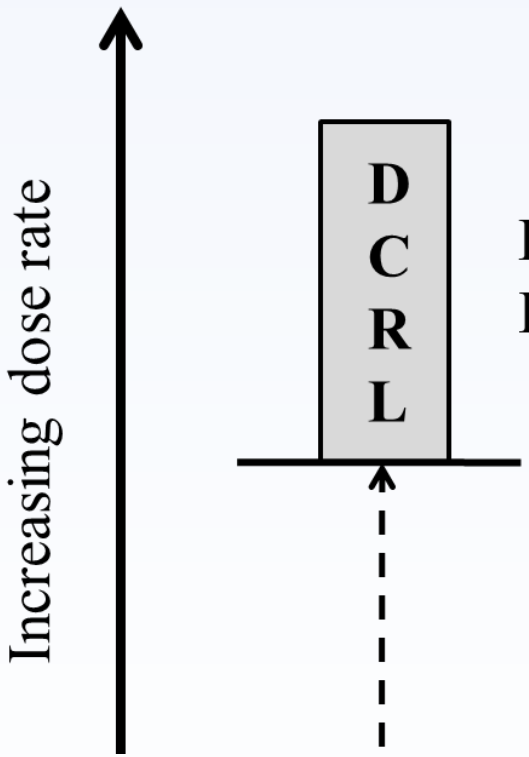
So how do we apply this…

Application questions that arise

- What are the protection objectives?
- Which exposure situation?
- What animals and plants are of interest?
- What biological effects of radiation are of relevance?
- What dose do they receive?
- What is the relationship between dose and effect on these animals and plants;
- How do we know that the original protection objectives have been met?

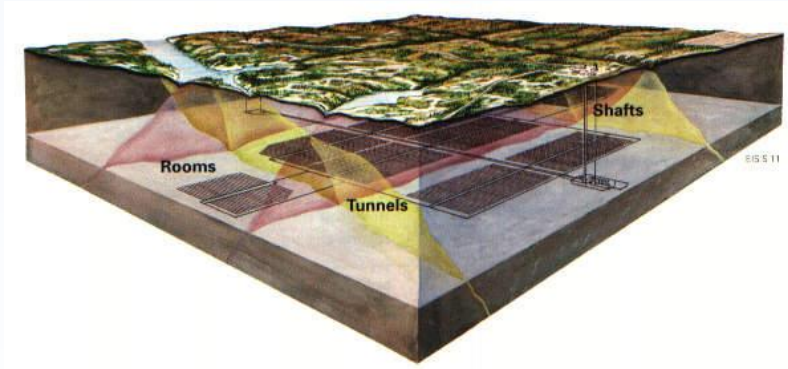
ICRP 124

Application in planned exposure situations



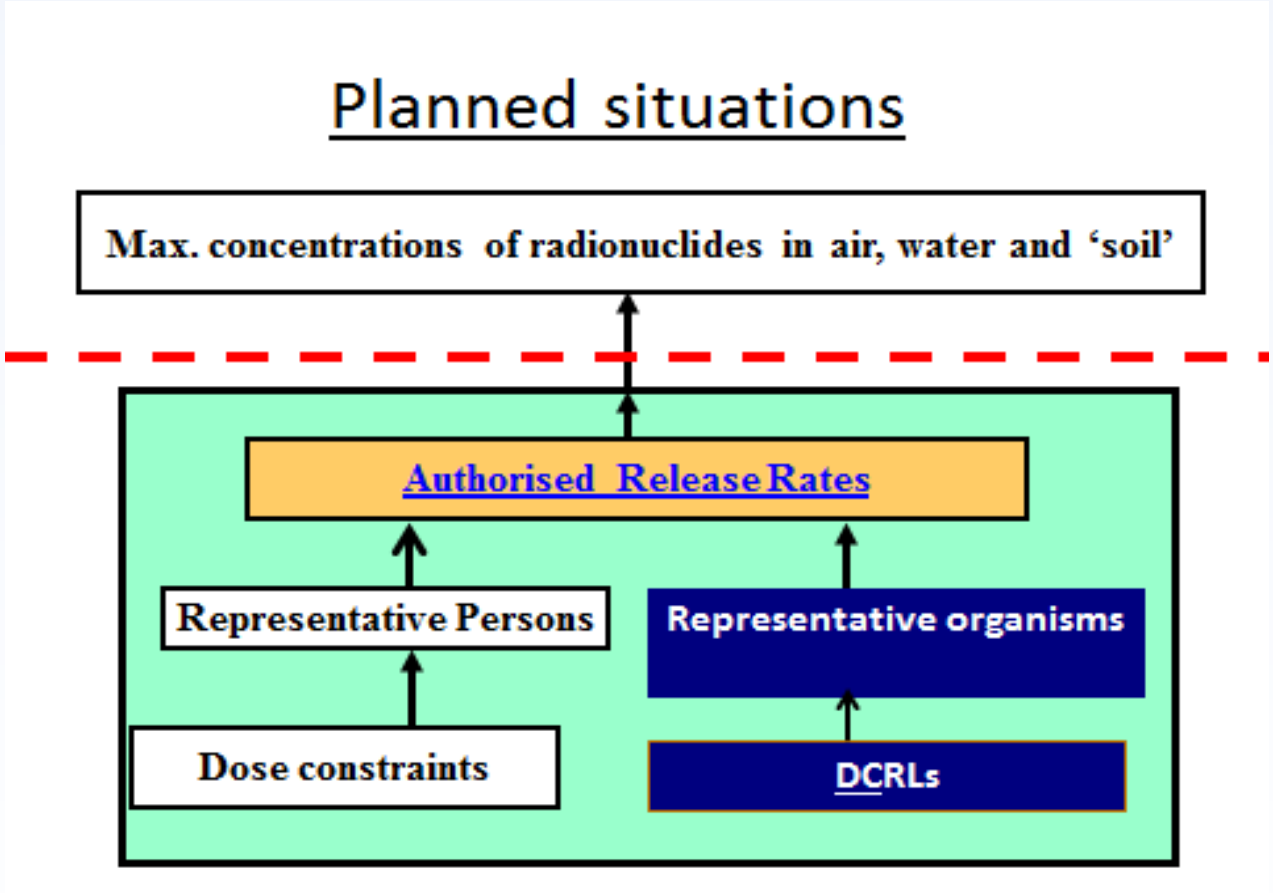
DCRL for relevant RAP

Reference point for the sum of all sources



ARTIST'S VIEW OF A DISPOSAL VAULT IN RELATION TO THE ROCK STRUCTURE

Application TG



This approach has been used…

OSPAR COMMISSION

Protecting and conserving the North-East Atlantic and its resources

Agreement on a Methodology for Deriving Environmental Assessment Criteria and their application

(OSPAR Agreement: 2016-07) [1]

Introduction

1. This agreement sets out the methodology for deriving criteria for the radiological environmental assessment of concentrations of radioactive substances in the marine environment of the OSPAR maritime area by OSPAR Contracting Parties. The agreement also describes how the criteria should be applied.

2. The practical aspects of the methodology should be reviewed and updated where necessary by 2020.

Methodology

3. The methodology developed by the International Atomic Energy Agency (IAEA) for deriving the environmental assessment criteria (EAC) is set out in Reference 1 ("the IAEA Methodology") and attached at Annex 1. The principles of the IAEA Methodology were agreed by the OSPAR Radioactive Substances Committee in 2013 subject to further testing and demonstration (see 'Application' below).

4. The scheme used in the IAEA Methodology to assess the radiological impact on humans and non-humans in an integrated manner is summarised in Figure 1.

IAEA TECDOC SERIES

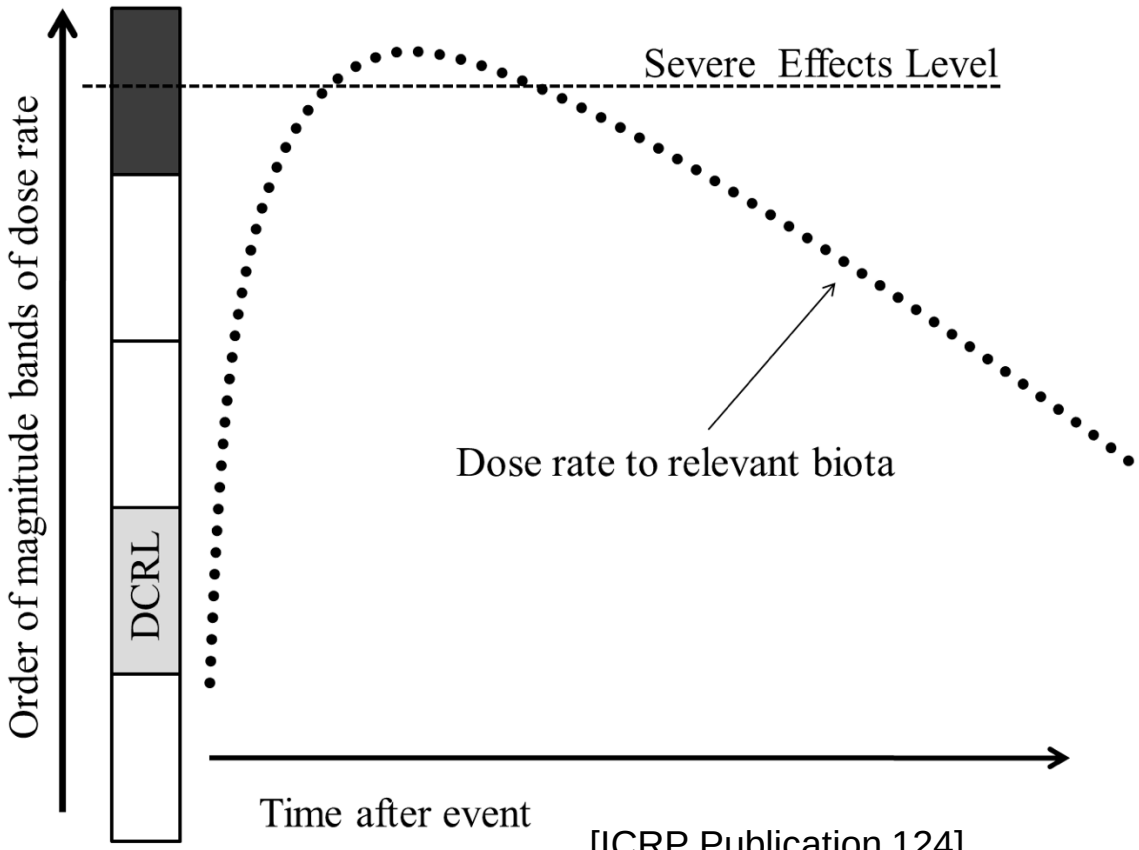
IAEA-TECDOC-1759

IAEA-TECDOC-1759

Determining the Suitability of Materials for Disposal at Sea under the London Convention 1972 and London Protocol 1996: A Radiological Assessment Procedure

IAEA
International Atomic Energy Agency

Application in Emergency Exposure Situations



[ICRP Publication 124]

Reference levels for humans

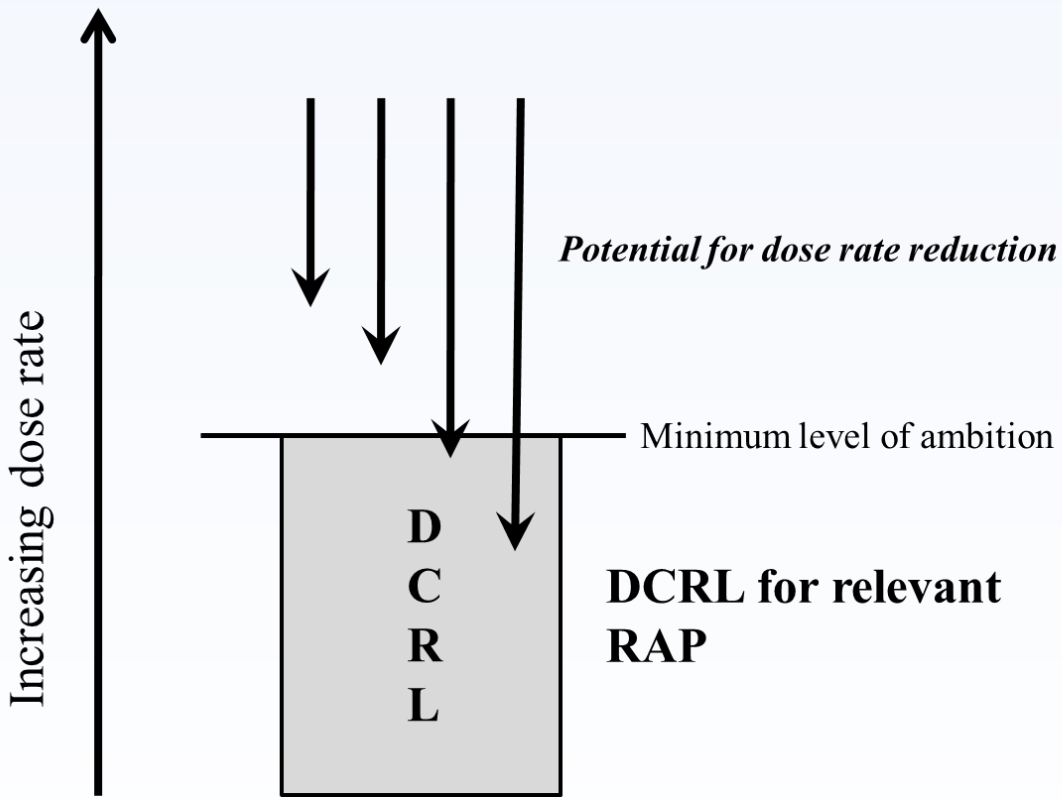
Emergency

After time

Dose rate (mGy d^{-1})	Reference Pine tree	Reference Wild grass	Reference Brown seaweed
>1000	Mortality [5 to 16 Gy LD_{50}].	Mortality [16 to 22 Gy LD_{50}].	Deleterious effects expected at very high dose rates. No LD_{50} data.
100 - 1000	Mortality of some trees after prolonged exposure.	Reduced reproductive capacity.	Effects on growth rate.
10 - 100	Mortality of some trees after very long exposure. Growth defects. Reduced reproductive success.	Reduced reproductive capacity.	Potential effects on growth rate and reproductive success.
1 - 10	Morbidity as expressed through anatomical and morphological damage. Prolonged exposure leads to reduced reproductive success.	No information.	Potential effects on growth rate.
0.1 - 1	No information.	No information.	No information.
0.01 - 0.1	No information.	No information.	No information.
< 0.01	Natural background.	Natural background.	Natural background.

ICRP 124

Application in existing exposure situations



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1 - 10	Morbidity [illegible]ssed through anato[illegible]ical and morphological damage. Prolonged exposure leads to reduced reproductive success.	No infor[illegible]n.	Potentia[illegible]ects on growth [illegible]
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DCRLS in existing exposure situations

- **ICRP Publication 124:**

"…*the Commission recommends that the aim should be to reduce exposures to levels that are within the DCRL bands (or even below, depending upon the potential cost/benefits) but with full consideration of the radiological and non-radiological consequences of doing so***."**

- **Ethics**
  - By considering radiological and non-radiological impacts on wildlife aim to do more good that harm in any management approach adopted

(Some) features to consider for existing exposure situations

- Need to be long lived radionuclides otherwise no need to control
- What are the key properties for the radionuclide and in terms of its chemical and physical characteristics
- Volume and area of contamination
- Location/position (e.g. depth) of contamination
- Number of people affected and their activities
- Wildlife presence and population affected
- Public opinion, legal situation, political constraints etc.

- Etc.

Case studies – what can we learn?

- **Not an exhaustive list:**
  - Andreeva Bay
  - Winterbeek radium site*
  - Gunnar Uranium Mine and Mill Site*
  - Little Forest
  - Maralinga*
  - Marshall Islands
  - Mayak
  - Midwest Uranium Mine and Mill site*
  - Montebello Islands*
  - Others?

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Environmental considerations and consequences of recommended recovery approaches?

Case Study 1: Andreeva Bay

- Radioactive waste storage site remediation in Northwest Russia
- Cs-137 and Sr-90
- Investigation of radiation exposure on wildlife – comparison to numeric criteria (based on humans)
- Locally relevant species:
  - Motley grass
  - Squat birch
  - Earthworm
  - Moor frog
  - Norwegian lemming

Case Study 1: Andreeva Bay

Remediation Option	Site	Representative organisms	Dose rate maxima, mGy d^{-1}	DCRL, mGy d^{-1}
Conversion	STS Industrial Area	Moor frog	67.2	10-100
		Motley grass	**14.6**	1-10
		Lemming	**148.9**	0.1-10
		Earth worm	0.6	10-100
		Birch	**43.9**	1-10
	STS Supervision Area	Moor frog	0.4	1-10
		Motley grass	0.1	1-10
		Lemming	1.0	0,1-1
		Earth worm	0.1	10-100
		Birch	0.3	1-10
Conservation	STS Industrial Area	Moor frog	38.1	10-100
		Motley grass	8.3	1-10
		Lemming	**84.4**	0.1-1
		Earth worm	0.4	10-100
		Birch	**24.9**	1-10

Case Study 1: Andreeva Bay

- Key findings:
  - All human assessments are within given criteria
  - Individuals of the wildlife species of interest however may be affected
  - On site population affected is small relative to wider area
  - On site population affected most by building and construction work

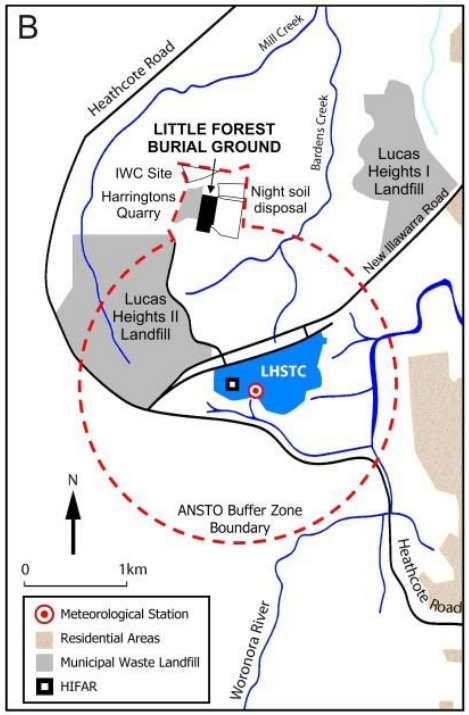
- Remaining questions
  - Trans-generational?

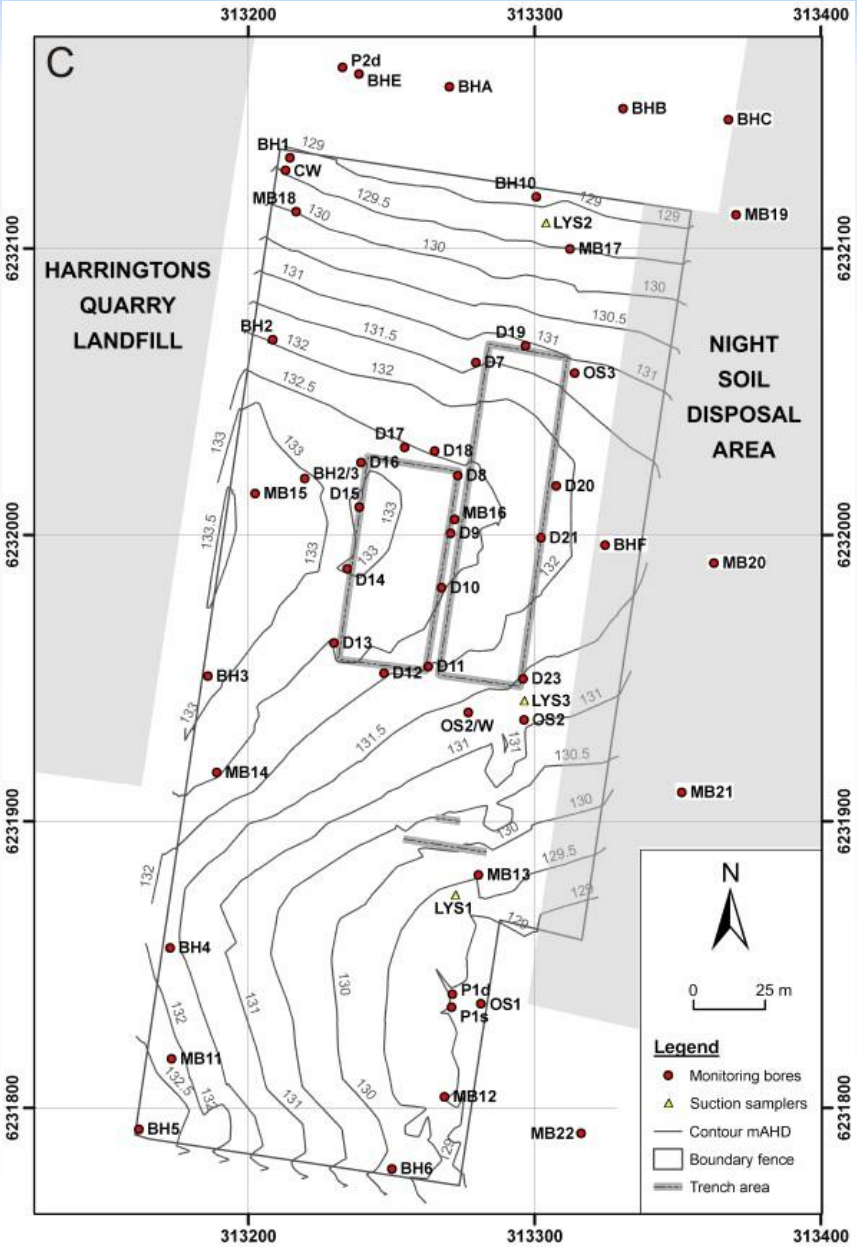
Case Study 2: Mayak

- Historic radioactive releases of wastes into Techa River (principal concern – Cs-137, Sr-90, H-3)
- Fish species, sediments, waters, zooplankton, algae and zoobentho studied (2011-13)
- Fish – weight, age, sex, fin colour, reproductive endpoints & cytological investigations
- Dose estimated as 220 microGy/day
- Pronounced changes in fish related to radiation exposure
- Levels of radionuclides did not exceed human dose limits or constraints
- Observed effects below relevant ICRP DCRLs
- Site complex – ongoing planned and existing exposure situations

Case Study 3: Little Forest Legacy Site

- New South Wales, Australia





- Acacia trees grow well until roots enter trench
- Dose estimates suggest potential biological effects may occur (not looked for) – values around DCRL
  - Amphibian situation similar

Case Study 3: Little Forest Legacy Site

- Findings
  - All human exposure scenarios below 1 mSv
  - Reference values not required to be set
  - Wildlife considered with most being below relevant DCRL
  - But… frog larvae and tree assessments highlighted potential to exceed the relevant DCRL
  - Direct comparisons of human and wildlife not possible but maybe wildlife need to be considered specifically
  - Again spatial and temporal extent may need to be considered
  - Example highlights that we may need to consider wildlife as a component of strategies for long-term management of existing exposure situations

Lessons learnt to date

- Need to examine on a case by case basis
- Derived CONSIDERATION Reference Levels may be used to help understand the likely consequences on wildlife
- Environmental protection may need to be considered as part of the management/decision making process
- Key is to understand what the consequences of management actions are likely to be on environment noting:
  - Actions to reduce radiological situation will likely have similar impact on wildlife BUT
  - Physical impact on biota or biodiversity?

- Decisions are value-laden varying on a case by case basis and dependent to a degree on local stakeholders

What do you consider?

- Population affected? Size, timescale, area etc.
- The nature of the exposure situation – normal, existing, or emergency;
- the area or zone (km^2) within which such dose rates were assessed to occur;
- the time period predicted for such dose rates;
- the principal reason for the assessment being made, such as the need to comply with some form of existing legislation;
- the type of managerial interest, such as fisheries management, agriculture, nature conservation, habitat protection, etc.;

What do you consider?

- The presence, or expected presence, of additional sources of chemicals, or other
- forms of environmental stress, in the same area;
- whether or not the assessment related to actual species, or simply to generalised animal or plant types; and
- the degree of precaution considered necessary for various purposes.

Summary

- A robust system has evolved to demonstrate radiological protection for humans and the environment
- Considering the environment in its own right is useful and facilitates communication
- **Embeds the ethical principle of "do more good than harm"**

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